ANNUAL REPORT OF THE

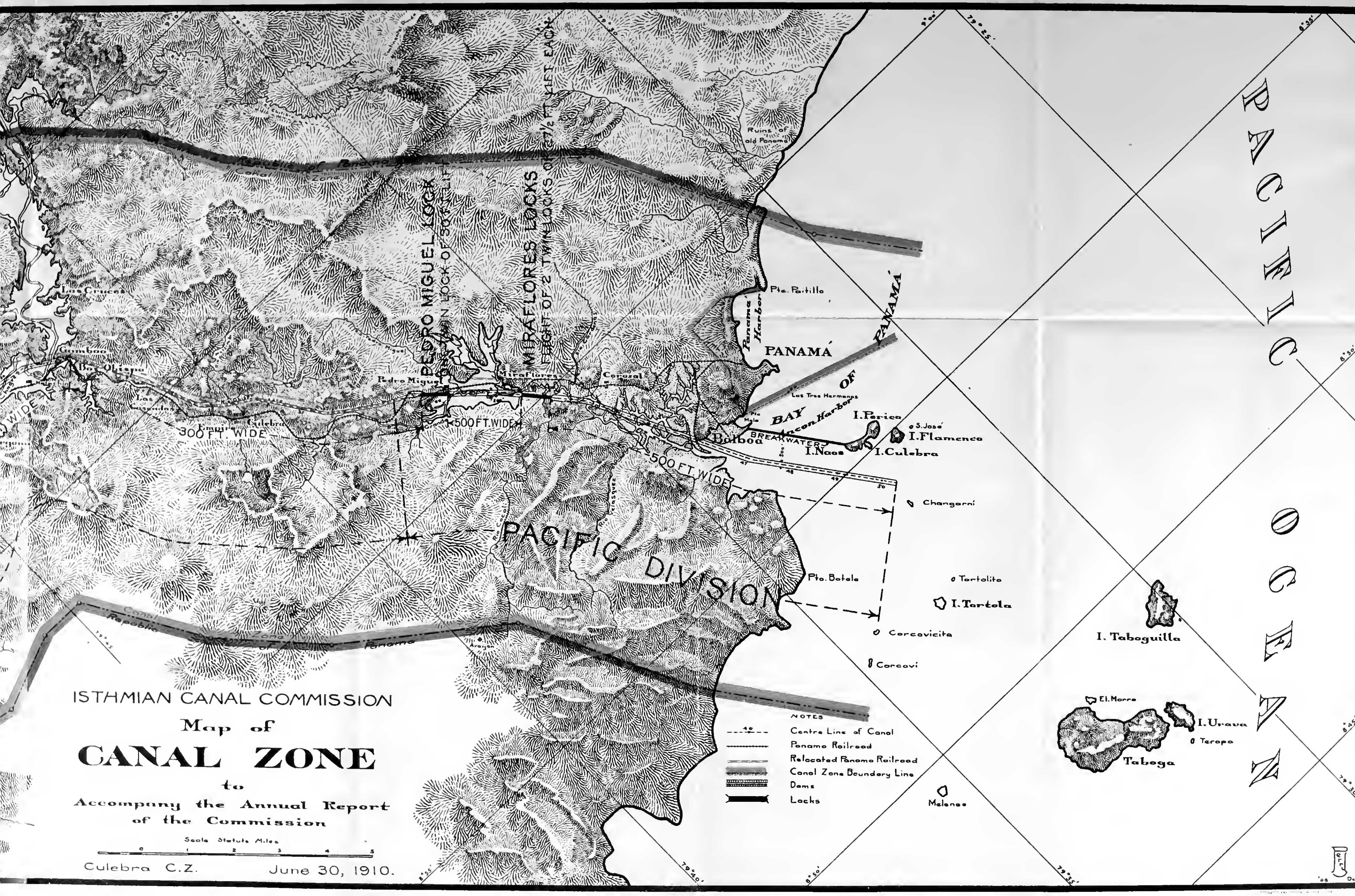
ISTHMIAN CANAL COMMISSION

FOR THE FISCAL YEAR ENDING JUNE 30

1910

WASHINGTON
GOVERNMENT PRINTING OFFICE
1910

ATLANTIC OCEAN
CARIBBEAN SEA
Bay de las Minas
Bay of Manzanillo
BREAKWATER
COLON
Colon Harbor
BREAKWATER
Pto Toro
Colon Harbor
500 FT. WIDE
Limon Bay
Mt. Hope
GATUN LOCKS
ATLANTIC DIVISION
P.R.R.
Rio Gatun
Gatun
Ahorca Lagarto
Lion Hill
Tiger Hill
Bohio
Frijoles
Tabernilla
San Pablo
Mamei
Gorgona
700 FT. WIDE
500 FT. WIDE
500 FT. WIDE
Rio Chagres
1000 FT. WIDE
Gatun Lake
Rio Trinidad
CENTRAL DIVISION



House Doc. No. 1030, 61st Cong., 3d Sess.

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ANNUAL REPORT

OF THE

ISTHMIAN CANAL COMMISSION.

Isthmian Canal Commission,
Office of the Chairman,
Culebra, Canal Zone, September 1, 1910.

Sir: I have the honor to submit the annual report for the Isthmian Canal Commission for the fiscal year ended June 30, 1910.

ORGANIZATION.

The Hon. Jo. C. S. Blackburn vacated his position as a member of the commission, by resignation, on December, 4 1909, and the vacancy was filled by the appointment of Mr. Maurice H. Thatcher on April 12, 1910.

The position of counsel and chief attorney was created and the duties defined by executive order of April 16, 1910. Minor changes were made in the organization along the general lines indicated in the last annual report, the most important being the abolition of the mechanical division as it formerly existed. The work at the Empire shops was limited to repairs to and manufacture of spare parts of steam shovels, and placed under the charge of the division engineer of the central division. To the Gorgona shops were added the car repairs from the Empire shops, and a superintendent placed in charge, under whose control were also placed the night hostling and repair of engines, the electric-lighting and the air-compressor plants, the boiler-inspection service, and material testing, with such mechanical designing as is necessary for manufacturing work. An inspector of shops was added to the organization, whose duties are to look after the economical distribution of work among the different shops, the distribution of tools in the shops, the necessities of additional shop facilities, and the adoption of standard shop methods.

A standard wage scale for employees on the gold roll was adopted and put into effect. After its adoption the heads of departments and divisions fixed the maximum limit of pay for the various positions considered by them as necessary for the proper conduct of the

work in their charge, and the pay of positions is now standardized, no variation being allowed except in cases where increased responsibilities and duties devolve upon its occupant.

CONSTRUCTION AND ENGINEERING.

The first division of the office of the chief engineer, under Lieut. Col. H. F. Hodges, assistant chief engineer, continued in charge of the design of the locks, dams, regulating works, and accessories.

A general description of the locks, as well as the drawings of the general designs for the upper locks at Gatun and for the locks at Pedro Miguel, were published in the annual report for 1909. During the year such detailed drawings were prepared as were needed by the working forces engaged in the construction of these locks. The general features of the intermediate and lower locks at Gatun and the flight at Miraflores have been adopted.

As it was concluded that an approach wall in prolongation of the wall separating the twin locks should be provided against which vessels should moor, and that the wing walls of the locks should not be utilized for this purpose, designs for the approaches have proceeded along these lines. The south approach wall at Pedro Miguel was designed of massive concrete, and the larger part of it is constructed. The northeast wing wall will also be of massive concrete, and reenforced concrete walls have been designed for the northwest, southeast, and southwest wing walls in the same locality. The designs for the remaining approach wall at Pedro Miguel, and those for Gatun and Miraflores, have been tentatively prepared.

The description and drawings of the valves adopted for controlling the flow of water into and from the locks are given in the last annual report. A contract was entered into on March 2, 1910, for all the frames for the gate valves required to control the main culverts for the upper Gatun and Pedro Miguel locks, and the delivery of the material began before the close of the fiscal year. A contract was entered into on July 10, 1909, for the frames and moving parts for two sets of Stoney valves; up to the close of the fiscal year but little of the material had been delivered.

Forty cylindrical valves were contracted for on July 10, 1909, the number required for the two sets of locks under construction. About 90 per cent of the contracted material has been delivered. Experience gained under contracts for the cylindrical valves brought about slight modification of the designs, by the substitution of cast iron for steel, and by changing the section of certain parts. Bids have been asked for furnishing the remainder of the ironwork required for all the valves for the main and lateral culverts, except the movable parts of the Stoney valves, which will not be purchased until the work is further advanced.

During the fiscal year, such general and detailed drawings of the lock gates as were necessary to advertise for all the gates required to fully equip the locks were completed. The advertisement issued on April 16, 1910, and bids were opened for delivery of the material and for erecting the gates in place. The lowest bid, that of the McClintic-Marshall Construction Company, Pittsburg, Pa., was accepted, and a contract made with this firm. The prices are 3.785 cents per pound for structural steel erected, 2.62 cents per pound for structural steel not erected, and $5,374,474.82 for the entire work. The advertisement called for the erection complete of all the gates in the canal, 46 in number, or 92 leaves, by January 1, 1914. Barring strikes and other accidents beyond the control of the contractors, the McClintic-Marshall Construction Company bind themselves to complete the work by June 1, 1913. Under the contract the work of erection at Gatun is to begin on January 1, 1911, and to be completed on February 1, 1913; at Pedro Miguel the work of erection is to begin March 1, 1911, and to be completed May 1, 1912; and at Miraflores work is to begin January 1, 1912, and to be completed June 1, 1913. Arrangements will be made to have the concrete work completed to meet this schedule.

The design of the machinery for operating the Stoney gate valves for the main culverts has been completed in detail. The valves will be operated electrically, and the machinery is arranged for either local or remote control, auxiliary hand apparatus being provided to close the gates should the machinery fail when a valve is in the raised position. The machinery for operating the cylindrical valves, of which there will be 120 in the six twin locks, is complete in all its details. In order to try out the machinery as designed, before purchasing the large number required, specifications have been prepared and bids invited for two machines of each class.

Much study has been given to the question of the machinery for operating the gate leaves. As the result, the recess in the wall into which the leaf fits when open was modified so as to permit of freer exit of the water around the miter post when the gate is near the position of rest, and a type of machine was adopted in which the force applied increases and the rate of motion decreases near the beginning and end of the movement. Briefly, the machinery adopted consists of a rigid horizontal strut connected to the upper girder of the gate leaf. The other end of the strut is attached to a large horizontal gear wheel near its circumference. As the large gear wheel is turned, the effect upon the strut is practically that of a crank upon a connecting rod. The rate of travel of the gate increases gradually from the beginning to a point just beyond the middle of the path between the recess and the miter. After passing its maximum, the rate gradually diminishes until just at mitering it becomes very small. It has been thought

desirable to provide on the gate leaves a positive lock which will hold them together against wave action, and at the same time it has seemed possible to arrange a locking device which will force the gates to meet perfectly at the miter, thereby reducing the care which is usually necessary in closing large lock gates to avoid a false miter. The device adopted is a new one and will be tried carefully before being extensively applied.

The general design for the spillway dam at Gatun was completed. The cross section of the dam is an ogee, made up of an arc of a parabola, a tangent, and the arc of a circle, the parabola being such that when the stream flowing over the crest is 6 feet or more in depth the nappe will adhere to the downstream face of the dam.

The trace of the dam is a semicircular arc, which secures not only the necessary development of crest, but also partial neutralization of the energy of the converging stream that will flow over it. To still further destroy the energy, two rows of baffle piers are placed on arcs of circles concentric with the dam. The crest of the dam is divided into 14 bays 45 feet wide, by 13 piers and 2 abutments, closed by means of Stoney gates operating on trains of live rollers moving on castings set in the piers. With the lake at plus 87, one bay with the gates fully opened will discharge 11,000 cubic foot-seconds, and all 14 fully opened will discharge about 154,000 cubic foot-seconds, or a greater amount than the maximum known discharge of the Chagres River continued during a period of thirty-three hours, which is 137,500 cubic foot-seconds at Gatun. Since the coping and top of the gates at upper Gatun and Pedro Miguel locks have been placed at plus 92, it would require a rise of 5 feet in the Gatun Lake to do material damage, and as it would take the maximum continued discharge of 137,500 cubic foot-seconds nine hours and twenty minutes to raise the level of the lake 1 foot, were no gates of the spillway opened during this time, ample provision has been made to take care of the floods that may occur, even should there be any negligence or delay in the operation.

As the spillway channel must be used for the discharge of the Chagres during the building of the main dam, the construction of the spillway dam will be one of the last parts of the work completed, and special means must be provided to permit its construction during the rising in the lake. Piers about 20 feet apart have therefore been built from the foundation projecting above low water, and of such design that stop planks can be placed between them, thus forming a coffer-dam, under the protection of which concrete can be placed. The design also contemplates the construction of four low-level culverts, three of them regulated by Stoney valves, and the fourth by a cylindrical valve, all like those to be used in the locks. These culverts will be installed

probably during the next dry season, and by their aid the lake level can be regulated during the construction of the remainder of the dam, the concrete being kept ahead of the slowly rising lake surface. The culverts will subsequently be filled with concrete.

The general plan of the machinery to be used in raising and lowering the Stoney gates on the crest of the spillway has been prepared. The machinery will be mounted in a tunnel in the main body of the dam for the purpose of protecting the parts of the machinery and the counterweights, this arrangement at the same time obviating the installation of cumbersome and heavy material on the footbridge which extends over the gates.

A design has been prepared for an electric locomotive, which it is thought will prove satisfactory to tow vessels through the locks and have full control of them from the time they approach until they are locked through to a point beyond which they can proceed under their own steam.

Work on the movable or emergency dams, the preliminary design of which was given in the last annual report, has been continued during the year, the various details settled, and the necessary drawings are now being prepared on which to invite bids for the delivery of material and erection in place.

For further details concerning the designs, attention is invited to Appendix A.

Investigation of the expenditure of water from Gatun Lake as affected by the design adopted for the locks has been carried on during the past year. The results indicate that during ordinary years there will be a considerable surplus of water, even in the dry season, and that the water supply of the worst-known dry season for the last nineteen years, namely, that of 1908, would be sufficient to maintain through the canal an average daily number of passages three or four times as great as the average number now passing the Suez Canal. This after making reasonable deductions for evaporation, leakage, power supply, and lockages.

The arrangement of the lifts in flights at Gatun and Miraflores increases somewhat the expenditure of water over what it would be were the locks separated into single lifts. The tidal effect at Miraflores also increases the expenditure considerably at that place. Nevertheless, the water supply is ample for the canal as planned, and a separation of the locks into single lifts would have carried with it a great increase in expense to bring about an unnecessary saving in the water supply. The accompanying Appendix B gives a detailed analysis of the effect of the use of the different lock chambers upon the water supply, levels, and lifts.

ATLANTIC DIVISION.

The work in this division embraces the construction of the locks and dam at Gatun, the quarry at Porto Bello, the sand supply at Nombre de Dios, the excavation between the locks and deep water in the Caribbean, the breakwaters for the shelter of shipping and protection of the channel in Limon Bay, municipal improvements in Colon and various settlements embraced within the territorial limits of the division, and such sanitary engineering construction as is prescribed by the sanitary department. The work is in charge of Lieut. Col. William L. Sibert, Corps of Engineers, U. S. Army, as division engineer.

Gatun locks.—The work of excavating the locks was continued during the year by steam shovels, and to some extent by dredges, resulting in the removal in lock chambers of 3,965,699 cubic yards in the dry and 435,178 cubic yards in the wet. In addition to this work excavation, there were removed 646,520 cubic yards of material in auxiliary work, including dredging in the French canal. The excavation in the upper locks was completed, including the trenching for the curtain walls and for the lateral culverts in that portion where these culverts were below the excavated area. With the exception of the trenching required for the lateral culverts, the excavation for the intermediate locks was completed. The excavation for the lower locks, exclusive of the approach walls, was also undertaken, and 375,000 cubic yards remain to be removed. The average cost of the excavation for the past six months, including plant charges and division expenses, was $0.6751 per cubic yard. In preparing the foundations for the concrete, including the excavation for the trenches for the lateral culverts, 33,843 cubic yards were removed during the past six months at an average cost of $2.515 per cubic yard, including plant charges and division expenses. Prior to January 1 this expense was included in general excavation, and no figures are available. The anchorages in the upper locks for tying the concrete to the natural rock, where the plans contemplated their use, were completed, as well as the filling with concrete of the curtain wall trenches around the upper part of the upper locks, in accordance with the plans adopted and noted in the last annual report.

At the close of the fiscal year 1909 the unloading cableways were in partial operation, and the erection in progress of the balance of the plant, which is described in the annual report for 1909. During the year the entire plant was completed in time to permit laying of concrete on August 24. The unloading cableways were unable to stand the strain required by operating them continuously at the speed necessary to secure the capacity called for in the specifications, and slight modifications were made to reduce the speed. Certain structural weaknesses in these and the lock cableways also developed, which were subsequently remedied.

The unsatisfactory operation developed during the early stages of their use resulted in the construction of an additional unloading plant just north of the cement shed, consisting of a sand bin having a capacity of 200 cubic yards, which was so arranged as to feed into the automatic cars, and two rock bins having capacities of 300 and 200 cubic yards, respectively; derricks were also erected, one at each of the bins, for unloading sand and rock from barges. The material is fed by gravity into cars, and the stone transported to the stock pile or to an auxiliary concrete plant placed at the south end of the locks. These were subsequently supplemented, in order to secure a proper supply of material, by a stiff leg derrick erected at Mindi, with proper docking facilities, for unloading sand and stone from barges to cars, and when the floods in November prevented the use of the French canal by tugs and barges arrangements were made for unloading barges at Dock 13, using a locomotive crane to pass the material from barges to dump cars. The Mindi plant was in service from November to June, and the plant at Dock 13 from December to April. To deliver material unloaded by these plant additions to the stock pile, and to unload in the stock pile sand secured from the Pacific division, a trestle 179 feet in length was constructed over the east sand tunnel.

The unloading plant has been operated twenty-four hours per day since April, when the searchlights were installed. The quantity of material handled was 2,458 cubic yards of large rock, 358,665 cubic yards of crushed stone, and 155,458 cubic yards of sand, of which the unloading cableways handled 314,854 cubic yards of crushed stone and 138,813 cubic yards of sand. The greatest output was in June; during this month the unloading cableways, five strands, handled 64,797 cubic yards of material, of which 22,521 cubic yards were sand. Operating on the basis of twenty-four hours per day, 48.65 per cent of the time was consumed in actual unloading operations, the balance lost waiting for barges (29.50 per cent) and in other delays (21.85 per cent); in other words, these cableways averaged 21.6 cubic yards per hour while in the service, or 44.33 cubic yards per hour of actual time in unloading. During the same month two derricks operating on the basis of twenty-four hours per day unloaded 25,400 cubic yards of crushed stone from the barges to the bins, or an average of 20.5 cubic yards per hour per derrick.

Difficulties were encountered with the automatic cars, due to lack of stability of the motor mounting, which set up a vibration and caused such excessive strains on the driving chains as would result in early destruction. This was remedied by extending the motor support and raising it by means of bearings on the axle. Due to the narrow gauge and lack of clearance, the king pin of the truck is high, resulting in occasional derailments when the car was started, and an extra

guard rail was placed where the most frequent derailments occurred, thereby eliminating the trouble.

Cement deliveries under the contract with the Atlas Portland Cement Company commenced in July, 1909, and with the cement shed full, the difficulties met with in the operation of the plant caused the supply to accumulate faster than it could be used. Rather than stop the deliveries, instructions were issued to lay as much concrete as possible, even at increased cost, and for the erection of an auxiliary plant, not only to increase the output of concrete sufficiently to care for the deliveries of the cement, but as an auxiliary to the plant in case of similar or other breakdowns. Work was prosecuted daily, including Sundays, until November, when Sunday work was discontinued. On September 6 a twelve-hour day for the permanent plant was instituted, and continued throughout the year.

The auxiliary plant consists of two 2-yard mixers similar to those used in the permanent plant, but steam driven. Material is handled from the cement shed and stock piles to the bins above the mixers by standard railroad equipment. The product of the mixers is handled by narrow-gauge locomotives with cars, the latter being small side dumps when concrete is placed in the floors, and platform cars holding from two to four 2-yard buckets when concrete is placed in the walls. In the latter case derricks are used in connection with this plant. It was installed, began operations in December, and has continued since on the basis of an eight-hour day.

The permanent plant laid, to the close of the fiscal year, 409,381 cubic yards, including large rock placed in the concrete, and the auxiliary plant, 104,422 cubic yards, or a total of 513,803 cubic yards. The total amount of concrete to be placed in the Gatun locks, including the approach and wing walls, is estimated at 2,046,100 cubic yards, so that the total amount remaining to be placed is 1,532,297 cubic yards.

The largest amount of concrete laid in any one month was in June, when a total of 89,869 cubic yards, bucket measurement, was reached. The permanent mixing plant had six of its mixers in use operating, theoretically, twelve hours per day, excluding Sundays, and in actual operation for an average of 11.82 hours per day. The number of cubic yards mixed was 62,202, or an average of 32.4 cubic yards per mixer per hour. The auxiliary-plant mixers operated eight hours per day, excluding Sundays, and mixed 23,390 cubic yards, or an average of 56.73 cubic yards per mixer per hour. The lock cableways, consisting of 8 strands, averaged 12.59 hours per day, excluding Sundays. Of this time, 79.8 per cent was in laying concrete, 7.1 per cent setting steel and forms, 0.24 per cent removing excavation, 2.62 per cent in moving, 1.3 per cent in repairs, and 8.94 per cent in delays. The actual number of cubic yards of concrete and large

stone laid by the cableways was 66,479, or an average of 31.42 cubic yards of masonry per strand per hour at work. The average cost of the concrete per yard in place for the year was $7.355, including plant charges and division expenses.

With a view to reducing the cost of concrete, instructions were issued in November to make arrangements to embed large stone, not less than one-man size, in the masses of concrete, and to an amount of about 20 per cent of the mass. This was begun in March, and up to the close of the year aggregated a total of 10,786 cubic yards. The stone was selected from material shipped from the central division for use in constructing the toes of the dam, and 2,458 cubic yards of large stone were procured from the Porto Bello quarry in May and June. On account of the excessive cost of the latter, $6.284 per cubic yard delivered at the locks, this source of supply was abandoned.

Collapsible steel forms are used throughout for the main and lateral culverts, and steel tower forms, which were purchased and erected under contract and are in place, are used for constructing the side and center walls.

Difficulty was experienced in handling the water as the excavation of the lock increased, and during the heavy rains in November and December, 1909, the pumps were unable to keep down the inflow. Two additional 12-inch pumps, direct connected to 220-volt induction motors, have been ordered, and it is hoped that when installed the pumping plant will then take care of the heaviest rainfall recorded.

The foundation for 150 feet of the south approach wall, in prolongation of the separating wall between the locks, beyond the opening of the center wall culvert, has been put in. To the south of this section of the wall the ground is low, requiring a fill which is to extend to the intersection of the center line of the locks with the old east diversion channel; about 90 per cent of this work is completed.

Stone and sand.—Crushed stone for the concrete of the locks and spillway was obtained from the Porto Bello quarry, which was developed during the year with a single face having a length of 2,500 feet and a maximum height of 140 feet. Considerable delay is occasioned by the fact that a large amount of "dobying" is required to handle the blasted material to and from the cars and to feed the No. 9 crusher—the largest installed as yet. To overcome this, and to increase the output, a No. 21 crusher was ordered in November, and is under erection. It is so placed that its entire product will be raised to the two No. 9 crushers, through which it will pass. Additional delay has been caused by the fact that the underpinning of the bins settled so as to render their use unsafe, necessitating the handling of the product from the crushers directly to the barges. The foundations have been made secure, so this source of delay is practically eliminated. The twelve-hour working day was increased

to sixteen hours on December 27 by operating two eight-hour shifts, and this was continued during the remainder of the year.

The total amount of stone quarried and crushed was 549,678 cubic yards, at an average cost for the last six months of $2.6283 per cubic yard delivered in the stock pile at Gatun, this cost including plant charges and division expenses. The greatest month's output was in June—a total of 74,184 cubic yards—when the plant for 70.15 per cent of the time, excluding Sundays, was engaged in crushing, 19.72 per cent undergoing repairs, and 10.13 per cent not working, waiting for barges and on account of other delays. The output of the crushers averaged 176.3 cubic yards per hour in service, and 251.3 cubic yards per hour crushing.

A new pressure pump was installed and pipe line laid for doing the necessary stripping by hydraulic process. Two boilers, a dynamo, engine, and condenser were also installed. A wireless station was erected and put in operation, and a clubhouse to be operated by the Young Men's Christian Association, and a commissary building were constructed.

Sand was obtained from Nombre de Dios and from the Pacific division. The original purchase consisted of a strip of land on either side and to the rear or south of Nombre de Dios, with the understanding that the town would be left intact. Later it appeared desirable to secure sand from the beach in front of the town, and on March 14 permission was obtained from the Panamanian Government to remove a part of the native houses and huts in the village, at an estimated cost of $5,000. On April 8 fire destroyed 73 buildings, which were replaced by new buildings in the rear of the town. The dredge *Nombre* sank in September and was raised in November, when she was converted into a 12-inch pipe-line dredge, and began pumping March 1, moving toward the deposits in the town. In addition to this, sand was obtained by a clam shell dredge temporarily mounted on a barge, by a locomotive crane, and by the dipper dredge *Chagres* operating until removed to Limon Bay in December. The total amount of sand obtained from Nombre de Dios amounted to 187,183 cubic yards, at an average cost for the last six months delivered in stock pile at Gatun of $1.9153 per cubic yard, including plant charges and division expenses. During the year, 101,748 cubic yards were transported from Balboa docks in the Pacific division and delivered in the stock pile at Gatun, at a total cost for the last six months of $1.2488 per cubic yard.

For the transportation of sand, stone, and cement, 3 tugs, 1 stern-wheel towboat, and 14 barges have been in use. Four additional barges are under contract.

Gatun dam.—Prior to January, 1910, the operations in the construction of the dam were practically limited to that portion between

the locks and Spillway Hill. It was decided in January that a larger amount of the material for the toes of the dam should be procured from the central division, this supply to be utilized so long as it could be economically furnished, and that such material should not be selected and confined to Bas Obispo rock as formerly, but should be run of the excavation. To accomplish this an additional number of steel dump cars were ordered to provide the necessary facilities for furnishing the largest amount of material that can be economically handled at the dam.

The discharge of the Chagres River was through the west diversion, and so continued until April 25, when the work in the spillway had been sufficiently advanced to permit of its use for this discharge. Efforts were then concentrated toward filling in the toes crossing the west diversion. Due to the fact that the rainy season had already set in, and that the bottom of the channel eroded as the opening narrowed, some minor slips occurred, but none of importance.

At the close of the fiscal year, the north and south toes of the portion of the dam east of Spillway Hill had reached an elevation of 65 feet above mean tide, and the hydraulic fill between the toes, an average elevation of 51 feet. West of Spillway Hill the north toe had been carried to an elevation of plus 30, and the south toe to an elevation of plus 35. Three dredges were pumping hydraulic fill into the west section, two from the south side and one from the north, and a fourth dredge, delivered under contract June 28, was put on the east portion of the dam, but will soon be removed to the west side of Spillway Hill until the hydraulic fill in the west portion is sufficiently high. The total amount of material placed in the dam during the fiscal year was, dry fill 2,577,234 cubic yards, estimated on car, or place measurement plus 25 per cent swell, and hydraulic fill 2,933,175 cubic yards, estimated on borrow pit measurements, less losses ascertained by cross section when practicable. The average cost for the last six months of the year for the dry fill, including plant charges and division expenses, was 28.19 cents per cubic yard; for the wet fill on the same basis, 32.54 cents per cubic yard.

Auxiliary work consisted in preparing the west valley for the reception of the hydraulic material by clearing and stripping off the top soil containing roots, excavating a cut-off trench along the axis 10 feet wide and varying in depth from 5 to 10 feet, and a bonding ditch along the foot of the western ridge. The surface of the low-lying areas was plowed. This preparatory work required the excavation of about 112,000 cubic yards over an area of 62 acres. An area of 138.45 acres south of the dam over which the dredges will operate in securing the interior fill was thoroughly cleared and grubbed. An area of 51.36 acres to the north of the dam was cleared for the same

purpose. Trestles aggregating 7,486 feet in length were constructed during the year.

Excavation for the spillway was continued during the year, resulting in the removal of 127,210 cubic yards. The excavation for the foundation of the spillway dam was completed, except at the extreme end; that for the curtain and side walls and for the floor was fully completed. Work on the floor and the side walls was continued, 53,632 cubic yards of concrete being placed, at an average cost for the last six months of the year, including plant charges and division expenses, of $8.602 per cubic yard. By April 25 the side walls, floor, and curtain walls were completed, and the foundation of the dam sufficiently advanced to warrant turning the Chagres River through the spillway. Considerable time was lost owing to the excessive floods of November and December. As the foundations of the dam are placed at elevation plus 10, and the other channels of the river cut off, the lake has been backed up so that its surface stands at from 16 to 20 feet above sea level.

Material is carried to the toes on the west portion of the dam by trestles in prolongation of these toes, across the channel through the spillway; as the trestles are liable to be carried out during the flood season, a permanent bridge across the spillway was constructed, consisting of six spans on concrete piers. The central truss, 100-foot span, formerly carried the old line of the Panama Railroad across the Gatun River.

The waters of the Chagres River passing through the west diversion had access to the French canal, and as silting resulted, the necessity for closing the passage was apparent, and it should have been done in the early fall of 1909; the failure to do so, however, before the high water of November, 1909, caused considerable silting of the French canal and the main channel in Limon Bay, and interfered seriously with the movement of sand and stone to Gatun. The December flood took out what was accomplished on the dam or levee in the interval between the floods. The work was finally undertaken in March, and the plan contemplates the construction of a levee connecting Spillway Hill with Mindi Hills, having an elevation of plus 25 at the spillway, and sloping to plus 21 in a mile; its length is to be 1½ miles; 126,000 cubic yards of material were placed at an average cost of 41.10 cents per cubic yard.

Channel between Gatun locks and the Atlantic Ocean.—Excavation in the dry in the Mindi section was continued until November 20, when work was suspended due to the cut being filled by the high water in the Chagres River, which had access to the French canal. There were excavated in the dry 91,572 cubic yards of earth, and 233,144 cubic yards of rock at an average cost of 62.18 cents per cubic yard,

including plant and division expenses. The deepest part of the cut had reached a depth of 42 feet below sea level at the time work was suspended.

The dredges in operation between the Mindi Hills and the Caribbean consisted of the 20-inch suction seagoing dredge *Caribbean;* 5-yard dipper dredge *Mindi;* three French ladder dredges, and the dipper dredge *Chagres* which was transferred on December 3, 1909, from Nombre de Dios and worked in the channel the remainder of the year. These dredges removed a total of 4,556,375 cubic yards of earth, and 399,285 cubic yards of rock from the canal prism, at an average cost of 23.60 cents per cubic yard, including plant and division expenses. There were also handled 3,206 cubic yards of earth from approaches to the Gatun docks, and 69,844 cubic yards of earth and 55,036 cubic yards of rock from the French canal. The dredges also removed a total of 247,537 cubic yards of earth and rock from the Cristobal terminals, and 501,928 cubic yards of earth and rock from the approach channel leading from the canal to Cristobal Harbor. The total silting between miles 1 and 2, as shown by surveys during the year, amounted to 493,365 cubic yards, and the fill for the year in mile 3 amounted to 461,922 cubic yards, and the total fill during the year is estimated at 3,500,000 cubic yards, of which 550,000 cubic yards resulted from the Chagres River flood in November, 1909.

An old French hull was overhauled and fitted with 8 Star well drills, and was worked successfully on subaqueous drilling. Four drills are placed on each side of the barge in quincunx order, separated 22 feet apart, the drills in each set of four being 15 feet apart. The barge drills, loads, and fires approximately 8 holes per day.

The dry dock shops were enlarged to provide for the installation of additional machines, and the fleet of dredges, barges, and tugs in charge of the Atlantic division was maintained in a satisfactory working condition.

Breakwater.—The location of the west breakwater for the protection of the waters of Limon Bay and the canal channel through these waters was definitely fixed on March 10, 1910, after examinations by soundings and borings covering an extended area. The plan originally presented contemplated a breakwater running out to a 44-foot depth. Another proposition was to build on a line parallel to the first but outside of it so as to reach 48 feet of water. The area between these two and well within the first was examined with a view to ascertaining whether better bottom might be secured. As a result of these studies and examinations it was decided to adopt the first, because a sufficient protected area beyond the 40-foot contour will be obtained, and because of economy.

Preliminary work looking toward the laying of tracks, clearing land, construction of quarters, and the establishment of a permanent water supply were undertaken preparatory to the construction of a trestle for the actual work of building the breakwater.

Municipal improvements.—The construction of the Agua Clara reservoir, with the exception of a filter plant, was continued along the general lines noted in the last annual report, and was completed during the year at a total cost of $202,147.05, exclusive of the filters. The pumping station on the Gatun River was in operation until May 28, 1910, when the supply was furnished from the new system. The new village of Gatun has been supplied with water from the new system, and about two-thirds of the water service required is completed.

The sewer system for New Gatun was also completed during the year, and considerable progress made toward the installation of plumbing in the buildings.

The Mount Hope-Gatun road was completed early in the year. The road was fenced on both sides from Mount Hope to Mindi, a total length of 5½ miles. Additional roads were constructed about Gatun to facilitate access to the commissary and corral.

The condition of the water in the reservoir at Brazos Brook was excellent throughout the year. Owing to a slight settlement of the dam and dikes, they were raised to elevation 55, a total of 1,715 cubic yards of earth being required for this work. Repairs were also made to the concrete apron under the 48-inch waste pipe.

To prevent erosion of the beach at Cristobal by wave action from Limon Bay, 173 concrete blocks were made and placed in line along the beach.

In addition, municipal improvements were undertaken in Colon, under an appropriation by Congress for the purpose.

Sanitary work consisted of constructing a new drainage ditch 500 feet long, and on an average 8,200 feet of ditch were regraded, cleaned, and widened each month.

For further details, attention is invited to Appendix C.

CENTRAL DIVISION.

The work of this division embraces all the excavation between the Gatun dam and Pedro Miguel locks, including diversion channels; construction of the Naos Island breakwater; clearing of timber from the channel and anchorage basin; municipal improvements in the various settlements included within the division limits, and such sanitary engineering work in the same area as is prescribed by the sanitary department. The work is in charge of Lieut. Col. D. D. Gaillard, Corps of Engineers, U. S. Army, as division engineer.

Due to the resignation of Mr. L. K. Rourke, assistant divisicn engineer, a reorganization of the division was made, effective May 1,

1910, by which the position of assistant division engineer was abolished on the date that Mr. Rourke's resignation became effective, and the position of a general superintendent of construction created. The five construction districts were consolidated into four, as follows: The Chagres River district, extending from Gatun to the Chagres River at Gamboa; the Empire district, extending from Gamboa to the Empire suspension bridge; the Culebra district, extending from the Empire suspension bridge to the railroad crossing north of Pedro Miguel locks; and the Pedro Miguel district, embracing the excavation between the railroad crossing and the locks, the dumps south of Pedro Miguel, and the construction of the Naos Island breakwater. The division includes the Culebra cut proper, extending from Gamboa to Pedro Miguel.

Chagres district.—The Chagres River by crossing the axis of the canal 23 times before it reaches Gatun forms a series of peninsulas, which, commencing at Gamboa, are known as Point 1, Point 2, Point 3, etc. Work on Point 1 was commenced February 24, 1908, and continued until June 15, 1909, when, because of annoyance from high water in the Chagres River, work was discontinued for the remainder of the rainy season. Work was resumed on January 20, 1910, and the excavation at this point was completed May 28, 1910; during the year 286,560 cubic yards were taken out. The total amount removed from Point 1 was 1,246,761 cubic yards.

Point 2, which lies between Matachin and Gorgona, was completed on May 25, 1909. The bottom of the cut was between 2 and 3 feet above the bottom of the Chagres River at a point where the latter crosses the cut, and the heavy floods of November and December deposited about 109,000 cubic yards of gravel. A steam shovel and orange-peel crane were put at work in the cut to collect this gravel for use as ballast on construction tracks, and for the building of roads; 56,238 cubic yards were removed and stored. In consequence of this gravel supply, the crushing plant previously installed at Bas Obispo was put out of service, as a material saving resulted from the use of gravel for ballast.

Point 3 lies on the east side of the Chagres River opposite Gorgona; excavation was begun on June 12, 1909, and continued until the close of the year, during which time 832,646 cubic yards were removed. There remained 157,522 cubic yards to complete this section, but as every slight rise of the Chagres River stops work, it became necessary to remove the tracks and shovels, as further excavaton could not be done economically at this season. The remaining material was loosened by blasting, and it is hoped that the floods of the Chagres will remove the greater part of it; such as may remain will be taken out by suction dredges when the waters in the lake reach a level permitting dredging operations.

Point 4 lies on the left bank of the Chagres River at Gorgona, and excavation was begun on June 2, 1910, 10,646 cubic yards being removed by the end of the fiscal year.

Point 5 is at Juan Grande, and excavation was commenced on June 2, 1910, 23,824 cubic yards being removed before the close of the year.

Point 6 is north of Juan Grande; work was commenced on May 2, 1910, and by the close of the fiscal year 46,741 cubic yards had been removed.

Hand work at Point Mamei was commenced April 15, 1910, and excavation by steam shovel on June 15. At the close of the fiscal year 8,315 cubic yards had been removed.

At Mamei work was commenced on September 17, 1909, and up to the close of the fiscal year 372,671 cubic yards had been removed.

The excavation at Caimito, which was in progress at the close of the last fiscal year, was continued, removing 338,675 cubic yards, which completed the work in this locality on April 22, 1910. The total excavation at this point amounts to 2,268,572 cubic yards.

During the fiscal year 5,899 cubic yards were removed from the San Pablo section, which leaves about 258,000 cubic yards remaining to complete the work in this locality. This can not be done until the Panama Railroad is abandoned, as this material forms the road-bed for the double tracks of the road.

The Cãno River section lies on the west bank of the Chagres River nearly opposite Tabernilla. Work was begun in December, 1908, and completed on September 24, 1909; the total amount of material removed was 707,031 cubic yards.

Work was commenced at Tabernilla on November 13, 1909, and carried forward to June 17, 1910, 392,490 cubic yards being removed. The Panama Railroad and the machine shop in this locality will prevent completion until after they are abandoned.

Near Buena Vista, on the right bank of the Chagres, are two hills, parts of the sides of which had to be removed in order to give the channel the necessary width and depth. Work was commenced with steam shovels on June 29, 1909, and completed November 10, 1909, by the removal of 153,026 cubic yards of material, which was transported to and dumped in the toes of the Gatun dam.

At Bohio, steam shovel work consisted in removing a rock hill near the north end of the village, which was commenced on September 4, 1909, and completed November 10, 1909, a total of 33,874 cubic yards having been removed.

A number of isolated elevations projecting but a short distance above the proposed level of the bed of the canal were removed by employees hired by the United States, or by contractors. In both cases, the laborers were furnished with portable narrow-gauge track

and old French Decauville cars; certain tasks were assigned, and payment made on the performance thereof. That done by the commission was commenced in January, 1909, and completed in November. The total amount excavated in the vicinity of Bohio amounted to 184,148 cubic yards.

A contract was made for the removal of 160,947 cubic yards from the canal prism between San Pablo and Bohio at a cost of 35 cents per yard. All were removed excepting 14,223 cubic yards.

Another contract was entered into for the excavation of 202,410 cubic yards between Tabernilla and Bohio at a cost of 21 cents per yard for earth, 25 cents per yard for soft rock, and 30 cents per yard for hard rock. No work was done by the contractor up to the close of the fiscal year.

A third contract was entered into on February 10 to excavate 397 cubic yards on miles 14 and 15 and miles 19 and 20 at a cost of 40 cents per cubic yard. This was finished March 15.

The total amount removed from the Chagres section from the beginning of operations in 1907 to the close of the last fiscal year was 9,497,673 cubic yards, leaving still to be excavated an estimated amount of 3,415,944 cubic yards. This estimated amount has been increased over the estimate of September, 1908, by 251,965 cubic yards, thus providing for excavating to elevation 39 above sea level instead of 40, made necessary on account of silting by floods, and by allowing 670,000 cubic yards for silting, due to the fact that during the rainy season of 1909, 152,000 cubic yards of sand and gravel were deposited by the river at Santa Cruz and Matachin.

At the beginning of the dry season the clearing, grubbing, and burning of trees in the channel of Lake Gatun were commenced, and resulted in clearing 950.4 acres. There still remained 162 acres to clear to complete the entire width of channel throughout the central division.

Culebra cut.—During the fiscal year 14,921,750 cubic yards of material were excavated from the Culebra cut, leaving 34,893,531 cubic yards to be removed in order to complete this section of the canal. The remaining amount includes an increase of 6,408,560 cubic yards over the estimate made in September, 1908. This increase is due to widening the canal north of Pedro Miguel lock so as to form a basin, adding thereby 932,572 cubic yards, and to allowing 5,475,988 cubic yards for slides and breaks, as a number of new ones developed during the year and could not be foreseen when the estimate of September, 1908, was made.

Previous to the fiscal year the movement of material into the prism was due almost entirely to slides caused by the movement of the top layer of clay upon smooth sloping surfaces of rock or other material harder than the clay. In addition to the slides, however, several

breaks have occurred in the banks of the canal. At the points where these breaks exist the underlying rock is of poor quality, intersected by vertical seams, or seams sloping toward the canal. Generally, the upper surface of the broken portion of the bank remained approximately horizontal, settling nearly vertically. The weight of the broken portion forces up and displaces laterally the material lying directly below it in the bottom or on the berms of the canal. As the material thus forced up is taken away the upper part gradually settles and moves toward the axis of the canal until the entire broken portion is removed.

In widening the canal so as to secure the requisite 300 foot bottom width the benches or berms that existed were removed, and while this method reduced to a minimum the amount of additional excavation it exposed fresh surfaces to the action of tropical downpours and at the same time increased the pressure at the bottom. It was expected that slides would occur, and in the estimates provision was made for them, but it now appears, from cracks that show in the upper surface adjacent to the faces of the cut, that sufficient allowance had not been made, and the estimates were corrected to meet the new conditions.

Of the slides proper, the most important is the one at Cucaracha, referred to in previous reports. The total area embraced since the commencement of operations is 47.1 acres. Prior to July 1, 1909, 1,125,017 cubic yards of material had been removed from this slide, and 639,239 cubic yards were removed during the fiscal year.

The next largest slide is on the west bank of the canal where the village of New Culebra was located. It has been caused by the movement of a large French dump into the canal. The area involved amounts to 7.3 acres. Prior to July 1, 1909, 118,024 cubic yards had been removed, and 327,540 cubic yards were removed during the year.

The third slide covers an area of 4.6 acres, and is located on the east bank of the canal directly opposite Whitehouse yard. Prior to July 1, 1909, 50,800 cubic yards of material had been removed, and 110,000 cubic yards were removed during the present fiscal year.

The fourth slide covers an area of 1.7 acres on the east bank of the Obispo diversion at La Pita Point, where the west slope of a hill broke away and commenced to slide toward the Obispo diversion. Steps were taken to remove this material before it could cut off the diversion, and 15,608 cubic yards were taken away.

Three bad breaks occurred during the year. On the west bank of the canal at the town of Culebra the break covers an area of 10½ acres, and during the fiscal year 1,500,388 cubic yards were removed, making a grand total of 1,680 000 cubic yards since the break began,

The second largest break, directly opposite that just described, covers an area of 11½ acres on the east side of the canal; during the year 314,184 cubic yards were removed, making a total from this locality of 480,202 cubic yards.

The third break was at La Pita Point, and permitted the waters of the Obispo diversion to flow into the canal for a period of three days, drowning out some of the shovels at the north end. This break aggregates about 40,000 cubic yards, but will not be disturbed until the dry season. A flume has been constructed of timber and concrete to carry the flow of the diversion past the break.

The total amount of material removed from all slides and breaks in the central division during the fiscal year amounted to 2,649,563 cubic yards, or about 15 per cent of the amount removed from the Culebra cut.

The floods seriously interfered with the progress of the work, and the one of December 26 overflowed the dike separating the cut from the Chagres River, cutting a channel through it about 200 feet long and 21 feet deep. As soon as the flood subsided steps were taken to rebuild it; this was accomplished, and by extra efforts the dike was maintained through the flood of December 30. Subsequently it was strengthened and carried to an elevation of 73 at the top of the rail. The track on the dike connects the relocated line at Gamboa with the main line of the Panama Railroad at Matachin. A new pump having a capacity of 18,000 gallons a minute has been ordered to be added to those already installed in the north end of the cut to handle the water accumulating from various sources.

During the year 17,749,306 cubic yards of material were deposited in various dumps. The most important of these are at Tabernilla, the relocated Panama Railroad between Gamboa and Caimito, Miraflores, and at Balboa. In addition, over 1,150,000 cubic yards of material removed from Culebra cut were taken to Gatun and deposited in the toes of the dam. Several dumps of limited capacity were opened up in the Chagres section to take care of the excavation in the immediate vicinity. The material deposited at Tabernilla and Miraflores outside of the relocation of the railroad was wasted. That dumped on the Panama Railroad relocation is used for filling trestles and for raising the embankments of the new line to the desired level; 2,351,334 cubic yards of material were useful for this purpose. Material deposited at Balboa is useful in that land is reclaimed from the ocean, which will in time be valuable. During the year 108 additional acres were reclaimed, making a total of 253 acres.

As previously reported, a breakwater was started from Balboa toward Naos Island with the object of cutting off silt-bearing currents from the excavated channel in the Pacific, thereby reducing

the cost of maintenance, and making navigation of the channel easier by protecting vessels from the existing cross currents.

Prior to July 1, 1909, the trestle had been constructed for a distance of a little over 2 miles, and during the fiscal year this trestle was extended 1,123 feet, giving a total length from shore of 2.4 miles. The end of the trestle was within 4,900 feet of Naos Island, and the filling extended to within 400 feet of the end of the trestle. Much trouble was experienced in extending the outer end of the dike, due to the sliding of the bottom when the weight of the stone filling was dumped from the trestle. This sliding has taken place at every foot of the last 4,000 feet of the dike, and a continual settlement of the roadbed for two or three months, after which it gradually diminishes, and finally ceases. The work so far accomplished has been of material benefit in securing the objects originally sought.

The average cost of excavation for the year was 66.99 cents per cubic yard, including plant charges and division expenses.

Empire shops.—On November 5, 1907, a force of mechanics was organized to work in the cut at night in repairing steam shovels; as the result, it is found that greater efficiency is obtained in steam-shovel work, and all repairs possible are made in the field without sending the shovels to the shop.

In the interest of economy, the repairing of steam shovels and the manufacture and repair of steam-shovel parts for the entire canal was transferred to the central division, effective October 1, 1909, on which date the Empire shops were transferred from the mechanical division, and all other mechanical work formerly handled at the Empire shops was transferred to the Gorgona shops.

Municipal work.—A wagon road 8 feet wide was constructed from Empire to Las Cascadas plantation, a distance of 2.6 miles, and completed on October 31. The construction of the road between Empire and Paraiso was continued during the year, and was 75 per cent completed on June 30. The road between Empire and Gorgona was continued, and 52 per cent completed. A suspension bridge across the canal at Empire was completed on July 31, 1909. It is constructed of four galvanized 2¾-inch steel cables strung over two wooden towers 60 feet high. The span is 600 feet long. This bridge was constructed for the purpose of carrying air and water mains across the canal, and is connected with the wagon road leading to the Las Cascadas plantation and Paraiso.

Sanitary work consisted of constructing 17,149 linear feet of ditches, regrading 116,028 linear feet of ditches, cleaning 1,453,841 linear feet of ditches and 56,441 linear feet of concrete drains, laying 7,289 linear feet of tile drains, constructing 56,441 linear feet of concrete gutters, and clearing 123,597 square yards.

Further data can be found in Appendix D.

PACIFIC DIVISION.

The work in this division consists of the construction of the locks and dam at Pedro Miguel, the locks and dams at Miraflores, the Ancon quarry, dredging for sand at Chamé, excavating a channel between the locks and below Miraflores locks to deep water in the Pacific, such municipal work as may be required within the territorial limits of the division, and such sanitary engineering work as may be prescribed by the sanitary department within the same area. The work is in charge of Mr. S. B. Williamson, as division engineer.

Pedro Miguel.—Work was continued in excavating the lock site and the approaches thereto from the south. When the excavation was nearly completed two slides occurred on the east side, delaying the work and increasing the amount to be removed by 75,299 cubic yards of earth and rock. The total amount of excavation during the year was 277,935 cubic yards by steam shovels, and 65,513 cubic yards by hand, of which 44,948 cubic yards were classed as preparing foundations. Excavation proper was done at an average cost of $1.188 per cubic yard, including plant charges and division expenses.

Subsequent to the completion of steam-shovel work the preparation of the foundations for the reception of concrete was undertaken by removing the loose rock which remained, and by excavating 42 trenches, 13 feet wide, 11 feet deep, and 137 feet long for the lateral culverts, and an area of 2,500 square feet to a depth of 5 feet below the floor level at the miter sills. The greater portion of the material was handled by pick and shovel into buckets or skips, which were unloaded into cars by the use of locomotive cranes or derricks. A small portion was handled directly into cars by a Thew shovel. In the preparation of the foundations a total of 64,084 cubic yards were removed, at an average cost for the last six months of $2.8193 per cubic yard, including plant charges and division expenses.

Bids were invited for the lock construction plant under date of October 8, 1908. The largest amount of concrete in the division is to be laid at Miraflores, and while in the selection of the plant the economical handling of this material was the guiding consideration, another important factor was that the plant should be capable of being adapted to the work at Pedro Miguel. Cantilever cranes were adopted, a general description of which was given in the annual report for 1909, and more detailed information will be found in Appendix E. A contract was entered into with the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, on May 8, 1909, for furnishing the material and for assistance in the erection. As designed for Miraflores, one arm of the berm cranes will transport material from the storage piles to the mixers on the cranes. The product will be passed by the boom arms to the side walls or to the chamber

cranes in the locks, which will place the concrete in the center walls. Both the berm and chamber cranes will handle forms and the steel or cast iron embedded in the concrete.

At Pedro Miguel the banks adjacent to the lock pit are such as to prevent the berm cranes from functioning as at Miraflores, so they are arranged with two cantilever arms, placed in the forebay of the locks, and used solely for transporting material from the stock piles to the mixers and for mixing. The chamber cranes place the mixture in both the side and center walls, as well as handle all the forms and steel or iron work. The concrete is carried from the mixers by narrow-gauge construction locomotives hauling two flat cars, each carrying a 2-yard bottom-dump bucket, which is taken by the chamber crane and the concrete deposited in the walls.

The contract required the delivery of one berm and one chamber crane by August 20, and one berm and two chamber cranes by September 20, 1909. Due to causes beyond the control of the contractor the deliveries were delayed, and as cement deliveries were based on the dates noted, when advised of the delays, arrangements were made to install mixers for building the lower guide or approach wall and for laying concrete in the floors in advance of the receipt of the construction plant. To this end three ½-yard mixers were employed in the approach walls, and two 2-yard mixers were installed temporarily, one on the east and one on the west side of the lock pit, for laying the lateral culverts and the floors.

The first berm crane was delivered on October 10, and the first chamber crane on October 25, 1909, but erection was interfered with by the excessive rains, so that it was not until April 4, 1910, that one-half of the regular plant was installed and began laying concrete in the west and center walls. The temporary mixer on the west side was then dismantled, but the one on the east side was continued in service until the close of the year. The entire construction plant at Pedro Miguel began operations on July 15.

The storage trestles in the forebay of the locks are constructed on both sides of and parallel to the canal axis, each having a height of 28 feet and a length of 880 feet available for storage. For this purpose 3,525 linear feet of trestle were erected.

Crushed stone and sand are delivered by trains made up of 12-yard dump cars; the stone is dumped on the inside, so as to minimize the average haul to the mixers. The total storage capacity is about 45,000 and 50,000 cubic yards of sand and stone, respectively, capable of supplying the mixers for seventeen working days of eight hours each.

The necessary tracks for the berm cranes required the laying of two parallel 5-foot gauge tracks 50 feet apart in the forebay. A total of 11,000 feet of narrow-gauge track was constructed from the forebay

to the lock chambers, necessitating the construction of 1,400 linear feet of trestles for these tracks, which are laid on an incline of $2\frac{1}{2}$ per cent.

The total amount of concrete laid was 166,869 cubic yards, of which 1,656 cubic yards were large stone placed in the mass. Of this total, the permanent plant laid 73,083 cubic yards on the basis of an eight-hour day. The rate per mixer per hour will be found in Appendix E. The average cost per cubic yard for concrete placed in the Pedro Miguel locks was $6.089, including plant charges and division expenses. The estimated amount of concrete in the locks, including approach and wing walls, is 858,600 cubic yards, so there remain 691,732 cubic yards to complete.

Steel collapsible forms are used for the main and lateral culverts, and wooden forms in built-up panels, 15 feet long and 8 feet high, are used for the construction of the walls. The panels are a series of uprights, 14 feet long, held together by walling strips and lagging. The latter is placed on the upper 6 feet the lower 8 feet acting as cantilevers on the concrete previously placed. The anchor bolts extend into the masonry for 2 feet, and are removed as the work progresses, leaving the anchor nut embedded. Each panel is used at least twelve times.

Filling back of the west wall was begun about the 1st of June. Material was obtained from the Ancon quarry site, and 9,616 yards were placed at a cost of 28.47 cents per cubic yard, including plant and division expenses.

The west dam at Pedro Miguel consists of two mounds or toes of all classes of waste material, a large percentage being rock, with the intervening space filled with selected material, forming an impervious core. The selected material is clay, excavated from the canal prism south of the locks, and is deposited from dump cars in layers about 6 feet deep, each layer being thoroughly wetted down and compacted. Within the year 51,827 cubic yards have been added to the impervious portion and 41,964 cubic yards to the toes at a cost of 38.60 cents per cubic yard.

A total of 99,703 cubic yards were removed below the locks at Pedro Miguel at a cost of $0.6345 per cubic yard. The bulk of this material was placed in the dam.

Miraflores.—The excavation for the upper locks of the flight at Miraflores was practically completed during the year, and the work of preparing the foundations, erecting concrete plant, and placing concrete begun. The total amount excavated was 234,731 cubic yards by steam shovels, and 59,098 cubic yards by hand, scrapers, and cranes; the actual excavation work being done at a cost for the last six months of $1.369. Of the total amount excavated, 157,483 cubic

yards were placed in the toes of the Miraflores west dam, and 121,080 cubic yards used as back fill.

A 20-inch suction dredge worked in the lower lock site until December 20, 1909. Because of the large number of bowlders encountered, and the character of the material, the output was small and the performance of the dredge unsatisfactory. As this dredge could be utilized to advantage in the Atlantic division, it was transferred, and arrangements are being made for excavating the remainder of the material by hydraulic means. The dredge removed 141,759 cubic yards at an average cost of 50.63 cents per cubic yard.

The work of preparing the foundation of the upper locks was begun as soon as the excavation was completed sufficiently, and consisted of cleaning up loose material and excavating for the lateral culverts and the areas above the miter sills. This work was done by a Thew steam shovel and by hand, the total amount excavated being 39,381 cubic yards. Excavation by steam shovels, classed as preparing foundations, was 24,655 cubic yards. The average cost was $1.947 per cubic yard.

The handling plant in these locks will consist of four berm cranes, two of which are in operation in the forebay at Pedro Miguel, and four chamber cranes, all of which are in use at Pedro Miguel. The tower and movable boom of one of the berm cranes is in place completely erected, and another on the west side partially erected. The cantilever arms will be placed on these cranes when the berm cranes at Pedro Miguel are dismantled and transferred.

On the east side of the lock a storage trestle about 3,200 feet long is under construction, and 1,400 linear feet of tracks for the berm crane have been laid and ballasted. Two concrete mixers will be installed in the storage trestle on the east side and will supply concrete to the berm crane for the placing until the mixers can be permanently installed on the crane after the work at Pedro Miguel permits. On the west side the berm-crane tracks and the erection of trestles for storage are in progress; the fourth crane is being assembled.

On June 1 concreting in the upper lock was begun on the floor and lateral culverts, the mixture being furnished by two one-half-yard mixers, as it is desired to complete the floors before the permanent plant is transferred from Pedro Miguel. The total amount of concrete laid was 1,630 cubic yards, at a cost of $7.393 per cubic yard. The estimated amount of concrete in the locks, including approach and wing walls, is 1,327,300 cubic yards.

A reenforced concrete power house at Miraflores has been finished, at a total cost, including equipment, of $486,096.82, and is now in operation. The building is 157 feet 6 inches long, 76 feet 6 inches wide, and the eaves are 39 feet above the generator-room floor,

beneath which is the basement. One end of the building and a portion of the turbine-room floor are of temporary construction, as the depth and width of the water turbines to be used have not yet been determined. The equipment is similar to that installed at Gatun, and described in the last annual report. It furnishes power for the operation of all the cranes, for the crusher plant at Ancon, and for the sand-unloading cranes at Balboa.

The west dam, extending from the head of the locks to Cocoli Hill, consisting of two mounds or toes made up of waste material obtained from lock excavation, mostly rock, and of hydraulic fill between them, was continued during part of the year. One hundred and fifty-seven thousand four hundred and eighty-three cubic yards were placed in the toes, at an average cost of $0.6774 per cubic yard, and 120,910 cubic yards of impervious material were added by the dredge. As this material was taken from the lock chamber, the expense was charged to excavation, Miraflores locks. Operations on the impervious part of the dam ceased when the dredge was taken out of commission.

Stone and sand.—Broken stone for concrete is furnished by the quarry which was opened on the west side of Ancon Hill, as described in the last annual report. The installation of the plant was continued during the early part of the year, and was practically complete in October, 1909, when a bad slide occurred on the face of the hill between the crushers and the storage bins, which delayed operations until the material which had moved could be excavated and some provision made to guard against future happenings of this kind. The slide necessitated the removal of 40,960 cubic yards of earth and rock, building a large amount of rock-fill cribwork, and replacing the conveyer connecting the crusher and bins, which was taken down to prevent damage. In opening up the quarry, 2,384 cubic yards were removed in preparing the necessary grade, and 194,112 cubic yards of stripping. The plant was finally installed and operations begun on February 10, 1910, and a total of 175,174 cubic yards of crushed stone was secured. The quarry is worked eight hours per day, and during June furnished 32,232 cubic yards, or 155 cubic yards per hour in service and 265 cubic yards per actual working time. As a large amount of screening was required for road surfacing in connection with municipal improvements, a small jaw crusher was installed, fed directly from one of the storage-bin pockets, which reduces the size to one-half inch or less. It has produced from 30 to 40 cubic yards of finishing material per day. The average cost of crushed stone delivered in the bins was $1.2682 per cubic yard, and delivered in the stock piles at Pedro Miguel $1.5023 per cubic yard, including in each case plant charges and division expenses.

Prior to the operation of the Ancon quarry stone for concrete was obtained from the Rio Grande quarry, which furnished broken stone for ballast and highway construction. This quarry was operated until February 10 and supplied 58,928 cubic yards, at an average cost of $1.28 per cubic yard. In addition, 3,750 cubic yards were obtained from the Atlantic division, at a cost of $2.39 per cubic yard.

Sand for concrete is obtained from a bay formed by Point Chamé, about 20 miles up the coast from Balboa. Sand is secured by a French self-propelling ladder dredge and loaded into barges of 500 cubic yards capacity, which are towed to Balboa, where it is removed from the barges to storage bins by means of rapid unloading cranes. Dump cars are loaded from the bins by gravity and the sand transferred to the storage trestles at the lock sites.

Under contract with the Cleveland Crane and Engineering Company three unloading cranes were furnished, each having a single cantilever 33 feet long projecting beyond the face of the dock. The cranes are operated electrically. Considerable delay occurred during the erection, due to the defects that developed in the machines, the correction of which necessitated changes. Structural weaknesses also developed, which required modification. The brakes originally furnished were not satisfactory, and air-controlled brakes were substituted. After the requirements of the contract were met the cranes were accepted and have since been strengthened in several particulars.

A total of 229,250 cubic yards of sand was secured during the year, of which 101,748 cubic yards were sent to the Atlantic division for use in concreting there. The average cost per cubic yard for the last six months is $0.7293 delivered in the bins and $0.9764 per cubic yard delivered in the stock piles, plant charges and division expenses included.

Hydraulic machinery.—The material to be removed in the 2-mile stretch of channel below Miraflores locks amounts to about 9,650,000 cubic yards, of which over 1,500,000 cubic yards are rock. As time is one of the important elements and it was impossible to assemble a sufficiently large dredging plant to complete this section within the limit fixed, an hydraulic excavating plant was selected as being not only the most expeditious method of handling loam overlying the rock, but the cheapest. It has an additional advantage in that the material removed can be utilized in reclaiming swamp lands adjacent to the line of the canal and belonging to the commission.

The plant as designed contemplates the washing of the material overlying the rock to sumps by means of a water jet under high pressure, and of dredging pumps elevating and conveying the material from the sumps through flumes. It consists of a central pumping station, pipe lines, hydraulic monitors, and dredging

pumps. The central station is located on the west bank of the canal, and in the center of the area to be excavated. There are mounted four Worthington horizontal, direct acting, triple expansion pumping engines with 24-inch stroke, 24½-inch water cylinders, and 19, 30, and 50 inch steam cylinders. Each pump is provided with a surface condenser and a direct acting single cylinder 12 by 20 by 24 inch vacuum pump. The pumps discharge into a common delivery pipe equipped with the necessary checking gate valves. Steam is supplied by four Babcock and Wilcox standard water tube boilers arranged in batteries of two each. Oil will be used for fuel, for which purpose two steel tanks of 2,000-barrel capacity each were erected on a hill at the rear of the station so as to feed the oil burners by gravity. The supply pipe from the pumping station is 3,600 feet long, made up of 2,000 feet of 40-inch and 800 feet of 32-inch lock-bar pipe, and 800 feet of 24-inch spiral riveted pipe. The main is provided with valves and tees suitably located for connecting branch lines leading to the monitors. The branch lines are 16-inch spiral riveted pipe laid in groups of three so that two giants may be continued at work while the third is being changed. The monitors are fitted with special deflecting nozzles. The dredging pumps, three in number, are 18-inch single suction centrifugal pumps, direct connected to a 655-horsepower induction motor. These pumps, with motors, switchboard, and priming pump, are all mounted on reenforced concrete barges specially designed by the division engineer and constructed for the purpose.

The Rio Grande River which originally occupied a portion of the area to be excavated has been diverted and a dike constructed across the south end to prevent the access of tide water to the area. After the removal of loam overlying the rock by hydraulic process, the rock will be excavated by means of steam shovel in the dry, that method being the most economical.

South of the area to be excavated by hydraulic means, the necessary depth and width of channel will be secured by ordinary dredging operations. During the year, there were employed at this work the 20-inch seagoing suction dredge *Culebra*, one 5-yard dipper dredge *Cardenas*, and four French ladder dredges. The total output of these dredges aggregated 6,914,384 cubic yards, of which 57,161 cubic yards were classified as plant, at an average cost of $0.2408 per cubic yard, including plant charges and division expenses. Bids were invited for the delivery of a ladder dredge having a capacity of 1,200 cubic yards per hour in sand and mud, for use in the division and subsequently for maintenance work through the canal.

Three methods are employed in breaking up the rock in this section so that it may be handled by the dredges; the rock lies in separate shoals of comparatively small area and volume. The first

method is by drilling and mining, in which case well drills operate through the overlying earth to a depth below the required grade; the holes are sprung, charged, and fired. By this means 274,339 cubic yards of rock were broken up, of which 19,392 cubic yards were removed by the dredges.

The second method is by subaqueous blasting, for which purpose a drill barge was constructed consisting of a steel hull 112 feet long by 36 feet 8 inches wide, provided with timber spuds—one at each corner of the barge. Three drill frames 38 feet high are located along one of the gunnels, arranged to move lengthwise of the barge on rails. Each frame carries a slide to which is attached a 5½-inch rock drill, and each slide is operated by a hydraulic ram and may be moved vertically through 10 feet. The drills are operated over a distance of 85 feet from one position of the barge, and the holes thus far have been spaced 5 feet apart on 6-foot centers located by means of ranges on shore. The barge began operations in March, 1910, and blasted over an area of 49,600 square feet. No dredging was done.

The third method is by rock breaking, and a Lobnitz rock breaker was placed in commission in August, 1909. It consists of a ram or cutter of steel fitted with a hardened steel conical point which is alternately hoisted and dropped. The device is mounted on a steel hull 100 by 28 by 8 feet. The tidal range requires the use of three sizes of rams, 30, 40, and 56 feet, weighing approximately 15, 16, and 19½ tons. The general practice has been to attack the surface of a rock shoal which has been exposed by dredging with the rock breaker at intervals of 4 feet each way, the points of attack being located by ranges on shore and permanent marks on the bay. The average limit of penetration thus far has been 3.12 feet. After the entire area of a shoal is gone over, the rock breaker is removed and the broken rock dredged out. The area covered during the year was 266,230 square feet, from which 25,515 cubic yards were dredged.

The Balboa shops and ship ways were operated during the year in the construction of some new pieces of plant, including the drill barge, erection of dump scows, construction of a floating repair shop and of a crane boat. In addition, the dredges, tugs, and barges belonging to the division were kept in good condition.

Municipal and sanitary work.—In addition to the municipal improvements carried on in Panama under a separate appropriation made by Congress, the principal municipal work was the erection of the Cocoli pumping and filtration station installed to augment the water supply for domestic and construction purposes furnished by the Rio Grande reservoir, the consumption from which had increased so as to materially reduce the pressure and supply at the south end.

The necessary pumps, treating and settling tanks, and filters, were erected at a total cost of $34,324.39.

Reenforced concrete reservoirs of 10,000 and 100,000 gallons capacity were constructed for the Palo Seco Leper Asylum and the Culebra Island quarantine station, respectively.

About 9,000 linear feet of road connecting Corozal with Pedro Miguel were completed, and a portion of the road connecting Corozal and Camp Diablo was added during the year. Extensive repairs were made to the Balboa and Sabanas roads.

The sanitary work consisted in cleaning 573,942 linear feet of earth drains; the construction of new earth drains requiring the removal of 2,661 cubic yards of earth; filling swamps and holes at various points necessitating the handling of 689 cubic yards of material, and the construction of 9,700 linear feet of cement drains, and 3,838 linear feet of tile drains.

For further information, attention is invited to Appendix E.

IMPROVEMENTS IN COLON AND PANAMA.

The municipal improvements originally undertaken in the cities of Colon and Panama were restricted to certain portions of the towns. The extension of Colon eastward of the improved section was prevented by sanitary regulations, and additional area for building purposes was considered necessary and advisable. Certain districts in Panama were built up without the extension of paving and of sewer and water mains, and the commission in 1908 submitted to Congress an estimate of $1,200,000 for extending the municipal improvements in the two cities. The act of March 4, 1909, making appropriations for the canal included an item of $800,000 for extending the improvements, and arrangements were made for undertaking the work during the dry season of 1909–10. The amount thus appropriated will be added to that already expended in the two cities and refunded at the end of the fifty-year period from collection of water rents.

Colon.—The work undertaken in Colon consists of the construction of the D street storm sewer at an estimated cost of $136,000. The sewer is to run from the sea at the Beach road on the north to Folks River on the south, with outlets at either end, and with the summit elevation at Eighth street. The flow through the sewer will be due to a head of 1.8 feet. The cross section of the sewer is semicircular in the lower half and rectangular in the upper half. At the close of the fiscal year the work was about half finished. In the construction of the sewer 6,473 cubic yards were excavated, 1,628 cubic yards of concrete laid, and 1,081 cubic yards of back fill made. No further work was done, as the final plans for filling in of the section east of D street were not completed at the close of the fiscal year.

Panama.—In the past year streets have been graded and macadamized, and sewers, water mains, and concrete curbs and gutters placed as follows:

	Paving.	Curbing.	Sewer mains.	Sewer laterals.	Water mains.	Water laterals.
	Square ft.	*Linear ft.*	*Linear ft.*	*Linear ft.*	*Linear ft.*	*Linear ft.*
Cocoa Grove district	70,130	3,920	1,683	872	2,494	1,185
Guachapali district	195,354	8,171	7,535	1,952	8,289	4,012
Avenue B	36,607	2,220	1,937	665	1,847	788
Santa Cruz district	91,116	5,062	8,078	1,952	7,692	4,058
District 1	24,240	1,275	1,496	628	1,195	677

The total cost of the improvements in Panama thus far undertaken aggregates $134,750.

For further details in connection with this work attention is invited to Appendixes C and E.

CONSTRUCTION OF THE NEW PANAMA RAILROAD.

The construction of a new line for the operation of the Panama Railroad is being done by the Panama Railroad Company under an agreement with the commission. It was in charge of Mr. R. Budd, chief engineer of the Panama Railroad, until he resigned September 21, 1909, since which date Lieut. Frederick Mears, First Cavalry, U. S. Army, was promoted to fill the vacancy created, and has continued in entire charge.

At the beginning of the year work was in progress upon the entire stretch from Gatun to Gamboa, with the exception of 8 miles through the valley of the Gatun River. As canal construction contemplated the closing of the west diversion and discharging the Chagres River through the spillway, the elevation of the floor of which was placed 10 feet above sea level, work on the relocation had to be arranged so as to give continuous communication at such times as the main line of the Panama Railroad is flooded. Work was therefore pushed in order to have a through route ready and available for use in case of necessity, and a temporary line on the 60-foot level was completed on April 23. In accomplishing this trestles were driven over the bottoms of the Quebrancha, the Brazos, the Baja, and the Gatun, and while of necessity they were outside the center line, they are so arranged that when filled these fills will form parts of the completed embankments. The filling in of all these trestles is under way, and no special difficulty has been met thus far except across the Baja bottom, where the material overlying the rock is very soft and treacherous. In the embankment across the Gatun River arrangements will be made for a bridge of three spans at the 95-foot level to allow for floods in the river, and one of the spans will be converted

into a lift span for navigation of the eastern arm of Gatun Lake. Temporary provision is made for floods by use of two of the girders formerly spanning the Chagres River at Barbacoas.

The trestles along the line from Caimito to the Gamboa Bridge were turned over to the central division for filling and were used as waste dumps for material from the cut; this portion of the line is practically complete. When flood conditions necessitate the use of the relocated line during the construction period connection between Gamboa and the present line of the railroad will be at Matachin over the construction track of the central division laid on the barrier which separates the cut from the Chagres River.

A number of permanent culverts of reenforced concrete were constructed to take care of the various streams crossed by the embankments.

In addition to 2,350,000 cubic yards of material dumped by the central division along the new line, 2,500,000 cubic yards were excavated and disposed of in the embankments, 17,000 cubic yards of concrete were laid, 25,000 linear feet of temporary trestle were constructed, and 15,000 linear feet of bridge piling were driven.

The completed track for the most part was ballasted by gravel secured during the dry season from a gravel pit opened on the Chagres River about 1 mile above the Gamboa Bridge, and from the Gorgona gravel pit operated by the maintenance of way department of the Panama Railroad. In all, about 42,000 cubic yards were secured, 18,000 cubic yards of which were placed on the line and the balance stored for future use.

The present plan contemplates the use of the 95-foot berm on the east side of Culebra cut as the location of the new railroad, and will, if this plan be adhered to, be finished by the central division as part of its work in connection with the excavation of the canal.

During the early part of the year it was decided to push the work on the section from Paraiso to Corozal in order that the present line of the railroad might be turned over to the commission for its use in moving spoil trains. This section of the line is about 4 miles long, and consists largely of embankments made from spoil from Culebra cut. It is practically complete, and is laid with new 90-pound steel rails and ballasted. To secure better alignment for the high line a part of the operated line was diverted. Two temporary stations were built to replace those of the old line which will be abandoned, one at Pedro Miguel and one at Miraflores.

For further details in connection with this work attention is invited to Appendix F.

MECHANICAL DIVISION.

The second division of the chief engineer's office has charge of all mechanical questions that may arise and supervises expenditures, the preparation of estimates, allotments for work, and cost keeping. It is under Mr. H. H. Rousseau, U. S. Navy.

To reduce delays on account of breakdown of machinery, plant, and equipment, which reflect largely in the unit cost of work, to a minimum, and to provide proper facilities for overhauling plant and equipment, as well as manufacturing necessary repair parts, large shops have been provided at certain points on the Isthmus, in which are employed 1,399 "gold" men and 2,992 "silver" men, or a total of 4,391. Other small shops employing one-half dozen or less men are distributed around the work where required. Cars converted into portable machine shops are also used, and in a similar way floating machine shops are provided for repairing marine equipment.

In general, the repair shops and equipment on the Isthmus are adequate to meet all requirements during the construction period. Nothing as yet has been done toward permanent shop facilities needed after completion of the canal, but in respect to this feature the commission at its one hundred and fifty-sixth meeting declared itself in favor of a policy which will, if adhered to, result in confining such permanent shop facilities to two points, one near each end of the canal, equipped to meet all the requirements of the United States in connection with the maintenance, operation, and protection of the canal, as well as the needs of the Panama Railroad, and those arising from the commercial use of the canal.

During the year special attention was paid to reducing the cost of maintenance and operation of equipment in the shops, including the standardization of salaries and wages, and of material and supplies necessary in construction repair work. In line with this policy two traveling engineers were appointed, who have been instructing and supervising engineers, firemen, and hostlers in all divisions, including the Panama Railroad, in the use of fuel and oil in connection therewith. A saving has resulted of fully 50 per cent in the amount of lubricants used, and of approximately 10 per cent in coal consumption per train-mile.

On April 29, 1910, the position of inspector of shops was established, and toward the latter part of the fiscal year a traveling engineer was appointed to inspect all fuel and oil consumption on the Isthmus except on locomotives and on marine equipment.

Gorgona shops.—As already noted, the Empire shops were transferred to the central division for the performance of all steam shovel, general repairs, and manufacture of steam shovel repair parts. Repairs to steel cars, formerly done at these shops, were trans-

ferred to the Gorgona shops, centralizing at the latter shops all repair work to rolling equipment other than steam shovels, as well as all manufacturing work. The car-repair yards at Las Cascadas and Gamboa were abolished; this work together with the medium heavy repairs to cars formerly performed at Pedro Miguel car-repair yard were transferred to Gorgona. The work at the Pedro Miguel yard is now confined to the lightest running repairs only. Under the new car-inspection service instituted, every car in the service is given a thorough inspection once a day.

To provide for the increased amount of work performed at the Gorgona shops, additions to buildings and equipment have been made when necessary. Among the former may be noted a new two-story building 42 feet by 100 feet erected for the storage of patterns aggregating 16,000, the estimated value of which is from $150,000 to $200,000. The old pattern-storage building was converted into a brass foundry, and three crucible melting furnaces installed therein. This arrangement enabled an enlargement of the iron foundry by the addition of 4,160 square feet of space. During the year 4,820,762 pounds of iron castings were made, at a cost of $0.02937 per pound, and 393,995 pounds of brass castings, at a cost of $0.1723 per pound, both exclusive of surcharge, but inclusive of the cost of patterns and material.

This division has continued the operation of all electric-power plants, except those at Gatun and Miraflores, furnishing current for about 31,000 lights. A pole line 5½ miles long was constructed between Gatun and Cristobal to convey current from the Gatun plant to the Panama Railroad Company's old plant at Cristobal, which was closed down.

The operation of the air compressors is also under this division, and 7,227,203,513 cubic feet of compressed air were generated during the year. Additional compressors were installed at Empire and Rio Grande plants, and 18,810 feet of main pipe line were removed and rebuilt on account of slides occurring through Culebra cut, and 3,600 feet of 8-inch main installed between the Balboa plant and the Ancon crushing plant of the Pacific division.

Appropriations.—The appropriations made by Congress for the Isthmian Canal and available to the close of the fiscal year 1909, amounted to $210,146,468.58, or 56 per cent of the total estimated cost of the canal, which is fixed at $375,201,000. On June 25, 1910, $37,855,000 were appropriated for the fiscal year 1910–11, leaving $127,199,531.42 of the estimated total cost of the canal to be appropriated. The total classified expenditures for canal work to June 30, 1910, amounted to $191,258,113.93, of which $31,188,426.37 were the net expenditures during the fiscal year covered by this report. Of the total classified expenditures to June 30, 1910, $25,699,450.81

were for plant and equipment for construction work, of which $4,388,511.55 were expended during the fiscal year.

Cost keeping.—Effective July 1, 1909, the subaccounts of the department of construction and engineering were contained in A, construction work, and B, plant and plant arbitraries were established as the basis for construction work. Thus, by taking up monthly the proper proportion of charges for plant and equipment expenditures, the plant charges will have been completely absorbed by the work on its completion.

The division cost of an item of construction work is made up of the cost of all labor and material directly applied to the work, a plant arbitrary and a proper portion of the general administration expenses, including expenses of the chief engineer's office and other general engineering expenses. To the division cost must be added, first, a proportion of the general expenses of the commission, including expenses of the quartermaster's and subsistence departments, examiner of accounts and disbursing office, and, second, a proper share of the expenses in the United States, and all other miscellaneous charges in order to arrive at the total cost.

For further general information concerning appropriations and expenditures, cost-keeping methods, and unit costs of work, the maintenance and operation of plant, equipment, and shops, attention is invited to Appendixes G, H, and I.

RIVER HYDRAULICS, METEOROLOGY AND SURVEYS.

The third division of the office of the chief engineer is charged with hydrographic and meteorological work, such general surveys as are embraced within the limits of any of the construction divisions, and such investigations as may be assigned to it. The division has been in charge of Mr. C. M. Saville, assistant engineer.

Gauging stations have been maintained at Gatun, Bohio, and Alhajuela, on the Chagres River, at Monte Lirio on the Gatun River, and Lagartera on the Trinidad River. River stations are maintained at Vigia and Gamboa for the purpose of predicting floods.

The minimum flow during the year at Bohio was in March, 1910, when the discharge was 1,220 cubic feet per second; the maximum was in December when it reached 90,000 cubic feet per second. The first freshet occurred on September 14, when the river reached elevation 61.6 at Gamboa. The crest of the November flood reached an elevation at Gamboa of 72.6 feet on November 19, 1909, and at Gatun an elevation of 21.50 above mean tide, flooding an area of 32.47 square miles. Three floods occurred in December; the first was reported from Vigia on December 6 and was due to rainfall in the Chagres basin above this station. The greatest flood of the year began on December 26; the river rose rapidly and within eight hours

after the beginning of the rise at Vigia the observer's house and water-stage register were washed away. At Alhajuela the crest of the flood reached elevation 121, or 2 feet higher than the flood of December, 1906; at Gamboa it reached elevation 78.2, or 3 feet lower than the flood of 1906. Before the high water of this flood had subsided another freshet occurred on the 30th and 31st, the crest of which reached an elevation of 112 feet at Alhajuela. These floods interrupted operation of the Panama Railroad, and communication between Colon and Panama was cut off entirely for a period of three days.

Three first-class meteorological stations were maintained at Ancon, Culebra, and Cristobal. Twenty rainfall stations were also operated, 9 supplied with standard rain gauges and 11 with automatic registers of the tipping-bucket type.

The temperature for the calendar year 1909 was below the normal, the average being 78° F. at Cristobal and Culebra, and 79° at Ancon. The minimum temperature was 61° F. at Culebra on March 1, 1910, and the maximum at Culebra, April 15, 1909, 94° F.

The rainfall for the calendar year was greater at all stations; the maximum noted was at Porto Bello, where 237.28 inches were recorded for the year. The maximum monthly rainfall also occurred at Porto Bello in December, 1909, registering 58.17 inches. Hail fell at Alhajuela on the afternoon of May 28, 1910. On the whole, there was a deficiency of wind movement during the year, though during a storm at Ancon on July 10, 1909, the wind attained a maximum velocity for one minute of 70 miles an hour, and for five minutes of 59 miles an hour, the greatest velocity of record on the Isthmus.

Slight seismic disturbances were of frequent occurrence during the year, very few of which, however, were physically observed in the Zone. Except in cases of minor local tremors, the records at Ancon harmonize with records in the United States, Mexico, and Europe.

Careful record of evaporations at various points along the line and the time of duration of fogs has also been kept.

The survey of the watershed of the Chagres was completed.

A triangulation survey was under way during the greater part of the year, undertaken for the purpose of combining all existing surveys for different parts of the work and tying them together in a complete survey of the Zone. Nineteen new stations were established which, with the three existing survey stations near the Colon wireless station, Colon light, and Toro Point light, will comprise the system from the Atlantic to the Pacific oceans.

The investigations which were started the previous year of the low divides at the headwaters of the Trinidad for the purpose of determining what steps, if any, should be taken to prevent overflow of the lake were continued. At one of the Cano saddles the distance

through the range at elevation 85 is 50 feet, and at no place between the 90-foot contours is it more than 100 feet. Investigation of this locality indicates that it will probably be necessary to increase the height, which can readily be done with material easily accessible. East of Gatun another saddle will probably require some reenforcement.

Attention is invited to Appendix J for more detailed information.

QUARTERMASTER'S DEPARTMENT.

The quartermaster's department is charged with the recruitment of labor; care, furnishing, and assignment of quarters; distributing fuel, commissary supplies, and distilled water; construction and repair of all buildings; requisitioning for supplies of all kinds, together with the receipt and distribution of them on arrival; cutting of grass and disposal of night soil and garbage as prescribed by the sanitary department, and the auditing of all property returns. The department is in charge of Lieut. Col. C. A. Devol, chief quartermaster.

Some minor changes have been made in the organization during the year. Effective July 1, 1909, the amount of construction work connected with quarters and buildings of other character had been reduced to such an extent as not to warrant the maintenance of separate gangs by each of the construction divisions for the erection of buildings, so that this and all repair work were transferred to the quartermaster's department. The operation of Dock 14, Cristobal, was transferred from the Panama Railroad to the quartermaster's department on December 1, 1909. Test inventories having disclosed unsatisfactory methods in handling and accounting for property, the storehouses at Gatun, Cristobal dry dock, and Porto Bello were transferred from the Atlantic division to the quartermaster's department, effective January 1, 1910; on the same date the storehouses at Balboa and Miraflores in the Pacific division were also transferred, thus placing all storehouses under the quartermaster's department. Requisitioning for skilled labor was transferred from the quartermaster's department to the chairman's office. The small return received for the outlay in maintaining gardens resulted in their elimination, and horticultural work is now attended to by the district quartermasters.

The average number of gold employees on the rolls of the commission during the past year was 4,369, and of the Panama Railroad 753, or a total of 5,122. During the year there were 2,890 separations from the service of the commission, and there were employed in the United States 1,099, on the Isthmus 1,092, and reemployments on the Isthmus 967, or a toal of 3,158, indicating that more than 60 per cent of the force was changed during the year, showing the usual unstable condition of the gold force.

Laborers recruited during the year aggregated 2,519; all were West Indians, the larger part of them from Barbados. The last recruiting was done in January, 1910, since which date immigration has exceeded emigration, and, as the work has reached its maximum, the present population of the Zone furnishes an ample labor supply. There has always been an independent immigration from the West Indian islands, but it was not until within the last four months that there has been any such movement on the part of European laborers. During this period, however, 2,000 have come of their own volition from Spain and Italy. From the beginning of the fiscal year there was a steady increase in the force, until a maximum—38,676—was reached on March 30, 1910, including the Panama Railroad Company and the relocation, and is the largest force on record. Since that time there has been a slight decrease, but the total effective force on June 30 was 35,578, as compared with 33,493 on June 30, 1909.

New quarters constructed during the year consisted of 19 houses for married employees, accommodating 38 families. Eleven buildings, accommodating 29 families, were converted into "gold" married quarters. The bulk of the new construction was at Ancon and Gatun. Under conditions of employment the commission was obliged to furnish married quarters to all employed prior to January 1, 1908, and all such employees have been supplied. Of those employed subsequent to January 1, 1908, there are 525 applications for married quarters. The expansion of the work at Gatun created a demand for additional bachelor quarters, and four type 18 houses, accommodating 192 bachelors at that point, were constructed.

As far as possible every building on the Isthmus has been utilized, and as the progress of the work has caused the number of employees at Culebra, Empire, and Paraiso to decrease, the vacant bachelor quarters have been utilized for what is termed "nonhousekeeping married quarters" for the use of employees working at points where they are unable to secure family quarters. Suites of two or three rooms are assigned to each family.

The number of negroes in quarters remains practically the same—4,925 bachelors and 1,067 families. There has been an increase of 1,300 Europeans occupying commission quarters.

The work performed for the sanitary department has increased, grass cutting now covering a largely increased acreage, and the increase in population has increased the amount of garbage to be removed. A new incinerator was installed at Empire, and new ones were also erected at Pedro Miguel and Miraflores.

A new corral was constructed at Ancon during the year. It is the largest on the Isthmus and will be useful after the completion of the canal. More animals have been available and used on construction work than at any previous period. There was an unusually heavy

loss of mules during the year, due to an infectious disease called "swamp fever."

There are 3,078 buildings in the Canal Zone owned by the commission, of which 1,147 were acquired by purchase from the French. The sum of $478,000 was expended for new construction and repairs during the fiscal year in completing 90 new buildings of every class of construction, clubhouses, hospital wards, corrals, engine houses, storehouses, fire stations, markets, schoolhouses, and quarters. Of these 90, 50 were constructed by contract, the contractor performing the labor and the commission furnishing the material. There has been a reduction in the unit cost, amounting to 30 per cent in the cost of type 14 and type 17 houses, and 33 per cent in the cost of type 18 houses, the types most commonly used for quarters. The cost of repairs to buildings aggregated $78,980. In the repair of buildings experience has demonstrated that in all but minor repairs the work can be handled more economically and expeditiously by traveling gangs with picked foremen. Four traveling gangs of carpenters and two of painters were organized.

The total amount of material received from the United States during the year aggregated 350,000 tons, valued at $10,103,552.34. The value of local purchases, including coal and oil, was $2,094,131.02; 345,185 tons of coal and 465,921 barrels of fuel oil were used. The stock in storehouses at the end of the fiscal year amounted to $4,691,-034.10. The experiment of annual contracts for standard articles of consumption has proven satisfactory; it has diminished the time between placing of the requisition and the delivery of material on the Isthmus, resulting in fewer shortages of stock in the storehouses.

The transfer of dock 14 from the Panama Railroad Company resulted in a reduction of charges, the rate on handling general cargo being reduced from 40 cents per ton to 32 cents per ton. Since the date of the transfer 100,000 tons of material have been handled over the dock by the quartermaster's department.

Additional storehouse facilities were added at Porto Bello, Gatun, Miraflores, and Balboa.

For further details, attention is invited to Appendix K.

SUBSISTENCE DEPARTMENT.

The subsistence department is charged with the operation of the Hotel Tivoli, 18 Isthmian Canal Commission hotels, 19 European laborers' messes, and 20 common laborers' kitchens, and is under charge of Maj. Eugene T. Wilson, subsistence officer.

One hotel was added during the year and one kitchen dropped. The supplies are procured from the commissary, belonging to the Panama Railroad Company, which is operated by the subsistence officer, who is also commissary for the Panama Railroad.

The Hotel Tivoli was operated during the year at a profit of $4,574.23. The total number of meals served at the line hotels, was 2,176,451, the price per meal being 30 cents. The cost for supplies per meal was 24.87 cents, and the expense in preparing and serving was 6.23 cents. There was a total increase of $43,964.31 in the cost of the food supplies to the line hotels during the year, or of 1.33 cents per meal. The expense in preparation and serving was decreased 0.69 cent over the preceding year. The total number of rations furnished in the European messes was 1,092,487, at a cost of 30.18 cents per ration for food and 6.60 cents per ration for expense. The number of rations served in the laborers' kitchens was 781,746, at a cost of 22.66 cents for food and 4.63 cents for expense. The total revenue from the line hotels, messes, and kitchens was $1,350,658.05, a decrease of $168,620.08 over the previous year.

For further particulars concerning the operations of the subsistence department, attention is invited to Appendix L.

EXAMINATION OF ACCOUNTS AND DISBURSEMENTS.

EXAMINER OF ACCOUNTS.

The duties of the examiner of accounts were outlined in detail in the last annual report and continued unchanged. The department is in charge of Mr. W. W. Warwick, examiner of accounts.

In the work of bookkeeping, improvements have been made in the classification of expenditures and the compilation of statistics. A distribution of the accumulated plant charges, formerly carried as one item, was made, so that the plant is now shown in the expenditure accounts by divisions and by units of the work.

Four inspectors have been engaged on inspecting accounts of bonded employees at all places on the Isthmus, and witnessing the transfer of responsibility from one employee to another. Cash accounts are inspected and verified at regular intervals during the year, and an average of four or five times for each account is considered sufficient, unless there is reason to believe that any particular account is being incorrectly kept. Coupon and meal-ticket accounts are inspected about once a month. Twice during the year the cash in the hands of the disbursing officer was counted, and in addition thereto at the time that the disbursing officer turned over all his cash to his assistant prior to going on leave, and on his receiving the cash from his assistant on his return. The money in the hands of the treasurer of the Canal Zone was also verified.

For the convenience of carrying on the work of time inspection, the Isthmus was divided into five districts, with senior inspectors located at Ancon, Empire, Gorgona, Gatun, and Cristobal. The number of time inspectors was increased from 41 to 46. All gangs

on an hourly basis were inspected three or four times a week, and some of them practically every day. In addition to inspecting the time books in the field, 12 men have been engaged in inspecting timekeeping in all timekeeping offices on the Isthmus to verify the accuracy of the pay rolls sent in, and an examination is made to see if pay rolls contain only the amount of time shown on the time rolls, and the time given on account of sickness, court attendance, etc., is verified from the certificates attached to such rolls.

One branch of the examiner of accounts' office has to do with the settlement of claims of employees on account of personal injuries, and this work has largely increased; the amount paid on account of such injuries was $96,810.33, and on account of death claims, $21,053.22. There was also paid on account of meritorious sick leave the sum of $16,010.30. A separate pay roll was established for the payment of compensation to injured employees, which is made up twice each month, and in case the disability of an employee continues for a year, or the greater part of a year, payment is made once a month. Claims on account of the death of employees are approved for one year, and payments made to the beneficiaries in monthly installments.

In this connection it is again to be noted that the classes of persons under the Isthmian Canal Commission given relief by Congress are fewer than in any other branch of the service covered by law, and has resulted in its application to imposing hardships in some cases. The requirement that all claims shall be acted on by the Secretary of Commerce and Labor has resulted in delays in making payments. The distance from Washington and the evidence which must be furnished to intelligently pass on the claims have caused much work which would not be required if settled on the Isthmus, where the facts can be readily determined.

The examiner of accounts is also auditor for the Canal Zone government. During the year more than $1,000,000 were kept on deposit in a bank in the City of Washington, to the credit of the treasurer of the Canal Zone. This represented, principally, money-order funds held pending settlement of the accounts with the United States Post-Office Department. Interest at 3½ per cent, to the amount of $36,867.94, was received on this deposit and credited as a revenue of the Canal Zone for use in public improvements and schools.

For further particulars, attention is invited to Appendix M.

DISBURSEMENTS.

The work of this department embraces the securing of and disbursing and the accounting for all funds paid out or collected, and the issuance of hotel and commissary books and meal tickets to the various departments of the commission. It is in charge of Mr. E. J. Williams, disbursing officer.

For details concerning the work of this department, attention is invited to Appendix N.

CIVIL GOVERNMENT.

The organization of the department of civil administration remains practically the same as outlined in the last annual report. Hon. Jo. C. S. Blackburn resigned, effective December 4, 1909, and Mr. Maurice H. Thatcher was appointed a member of the commission on April 12, 1910, and assigned as head of the department of civil administration on May 13, 1910.

No congressional legislation of importance affecting the Canal Zone was passed during the year. Among the most important executive orders promulgated are the order of the President of July 30, 1909, amending section 149 of the Penal Code of the Canal Zone, which prescribes the penalties for murder in the first and second degrees; the President's order of November 23, 1909, penalizing the recruitment of labor in the Canal Zone for service in foreign countries; the President's order of April 16, 1910, defining the powers and functions of the counsel and chief attorney and the prosecuting attorney, amending the existing provisions of law respecting the filing of informations and the execution of criminal process; the President's order of January 26, 1910, providing for charging an equitable proportion of the cost of sanitary improvements to property owners in the district in which sanitary improvements are made. A board of local inspectors was created by the President's order of October 2 for the examination and licensing of masters, mates, engineers, and pilots of steam vessels navigating the waters of the Canal Zone. The position of executive secretary was abolished by order of the Secretary of War on May 24.

Some of the matters taken up with the officials of the Republic of Panama and satisfactorily adjusted are the stationing of Zone police at Nombre de Dios in the Republic of Panama, and the adoption of sanitary regulations; the amendment of the agreement with Panama for the maintenance and operation of Santo Tomas Hospital; the maintenance of the insane of the Republic of Panama in commission hospitals; the verification of the survey of the Canal Zone boundaries, and the enforcement of the executive decree of Panama prohibiting the recruitment of labor in the cities of Panama and Colon. The relations of the commission with the Republic of Panama and with foreign representatives continue satisfactory.

Posts, customs, and revenues.—The postage sales for the fiscal year amounted to $83,847.10, an increase of $9,519.70 over the preceding year. During the same period 151,622 registered letters and parcels were handled, of which, approximately, 45 per cent was official matter. Money orders to the number of 207,220 were issued, totaling $5,228,562.15 in value, on which fees aggregating $22,980.96 were

collected. The preceding year's issue was exceeded by $61,812.69. Of the orders sold, $3,976,891.63 were payable in the United States and foreign countries, except Martinique, and orders amounting to $1,247,610.22 were payable in the Canal Zone. A convention was concluded on August 1, 1909, providing for the direct exchange of postal money orders between Martinique, the French West Indies, and the Canal Zone, since which time orders amounting to $4,060.30 have been drawn for payment in Martinique. The post-offices of the Canal Zone are extensively used by employees as depositories, there being on June 30 unpaid money orders aggregating $323,311.15, drawn to the order of the remitter and payable at the office of issue, in the various offices on the Zone.

Vessels to the number of 237 entered at the port of Ancon, with a total tonnage of 400,910, and 238 vessels cleared with a tonnage of 399,690. At Cristobal 235 vessels entered with a tonnage of 636,191, and 232 vessels cleared with a tonnage of 625,958. No duties or customs fees were collected.

At the close of the fiscal year there were 2,783 leases in force, of which 1,892 were for building lots and 884 for agricultural lands, an increase of 686 in the total number of leases over the preceding year. Rents collected during the year amounted to $27,282.29, a slight increase over the amount collected for the year ended June 30, 1909. An appropriation of $75,000 was made by Congress near the close of the year for the purpose of making a general land survey of the Canal Zone.

On account of general taxes and licenses, $107,642.58 were collected, an increase of more than $8,000 over the preceding year.

During the year 38 estates were settled, and on June 30, 17 were in course of settlement, involving the handling of $6,531.24.

Police and prisons.—On June 30, 1910, the police force consisted of 259 employees. A reorganization of the division was made, effective February 1, 1910, at which time the Canal Zone was, for police purposes, divided into four districts, coextensive with the administrative districts as established by the order of the President dated March 13, 1907, the changes in the organization being made with a view to concentrating the responsibility. The number of arrests made during the year was 6,947, an increase of 672 over the previous year, or about 10 per cent, which may be attributed in part to the increased population of the Zone. Of those arrested, 5,467 were subsequently convicted, 1,211 were dismissed, and the cases of 34 are still pending. Of the remainder of those arrested, 40 were confined in the insane asylum at Ancon, 22 were turned over to the military authorities, 14 fugitives from justice delivered to the Panama Government, and 148 persons arrested at Porto Bello, in the Republic of Panama, turned over to that Government for trial. On the charge of murder 18 arrests

were made; 5 were convicted; 8 acquitted; 1 dismissed; 1 confined in the insane asylum, and 3 are awaiting trial.

At the close of the fiscal year there were 138 convicts confined in the penitentiary at Culebra, who have been kept at work on public roads, grading, etc. Eight pardons were granted during the year and two sentences commuted.

Schools.—During the year 12 schools for white children and 15 for colored children were maintained, and on October 1, 1909, there was an enrollment of 745 and 1,067, respectively. School gardens have been maintained in connection with a number of the colored schools, and have been productive of good results.

Fire protection.—During the year a paid fire company was established at Gatun and a fire-alarm system installed; two new volunteer companies were organized at Gatun, and one volunteer company was discontinued at Ancon. On June 30 there were 19 volunteer companies, with a membership of 324. There were 123 fires during the year, of which 12 were in Panamanian territory; the value of government property involved, as reported by the fire chief, was $1,174,017.19 and the total loss resulting from fires, $2,796.04.

Public works.—There were 201 sewer and water connections made in Panama during the year, the total number on June 30 being 1,493, with 84 applications for connections pending. The total collections from water rents from private consumers for the first three-quarters of the year were $50,159.15, and the net amount of the bills rendered for the quarter ended June 30, 1910, was $16,384.

In Colon during the year there were 84 connections made, the total number on June 30 being 548, with 28 applications for connections pending. The total collections of water rents from private consumers and from the commission and the Panama Railroad Company during the first three-quarters of the year were $56,477.45, and the net amount of bills rendered for the fourth quarter was $19,507.90. The extension of the water, sewer, and paving systems in Panama and Colon authorized by Congress will require amendment of the existing agreements with Panama for the collection of water rents, and new contracts will be submitted as soon as practicable.

During the year 244 private sewer and water connections were made in the Canal Zone, the total number now being 516.

Prosecuting attorney.—During the year the prosecuting attorney filed 251 informations against 313 persons, which resulted in 205 convictions. The prosecuting attorney also represented the Government in 71 criminal cases which were appealed to the circuit courts from the district courts.

Courts.—The supreme court held 19 sessions during the year. It confirmed the decision of the circuit court in two criminal cases, and reversed the decision of that court in one criminal case. Three civil

cases were pending at the beginning of the year, 13 were filed, and 10 were disposed of.

In the circuit courts 382 criminal cases were filed; 249 convictions were secured and 39 were acquitted; 68 cases were dismissed, and 26 cases were pending on June 30. Of 397 civil cases filed during the year, 301 were disposed of and 96 were pending at the close of the year.

In the district courts, 6,732 criminal cases were filed; 5,215 convictions secured and 812 were acquitted; 366 cases were appealed to the circuit courts, and 9 cases were pending on June 30. During the year 1,123 civil cases were filed, 1,055 were disposed of, and 68 were pending at the close of the year.

Canal Zone funds.—At the beginning of the fiscal year there were $197,531.22 on hand in the Zone treasury, and $394,422.23 were collected during the year. The expenditures amounted to $518,771.57 for public improvements, schools, maintenance of administrative districts, and contingent expenses in the postal service.

For further particulars concerning the work in this department, attention is invited to Appendix O.

DEPARTMENT OF SANITATION.

The work of this department embraces sanitary work in the cities of Colon and Panama and, except oiling, it designates the sanitary work to be done in the Canal Zone in order to accomplish the desired ends, exercising such supervision as is necessary to see that the work is satisfactorily performed; in addition, the department has charge of hospitals and quarantine. The department is in charge of Col. W. C. Gorgas, Medical Corps, U. S. Army, as chief sanitary officer.

The work in the terminal cities consists of cutting grass and brush, oiling pools, and constructing and maintaining ditches for drainage purposes, removal of garbage and night soil, fumigation and street cleaning. On account of the juxtaposition of Cristobal and Mount Hope to Colon these are included in the Colon area, and for the same reason Ancon in incorporated with Panama.

In the Canal Zone, the quartermaster's department expended under the direction of the sanitary department $127,923.28 in grass and brush cutting in and about commission settlements, and $47,009.87 for the removal of night soil and garbage. The amount expended for the removal of garbage and night soil in native settlements was $25,414.51. In the maintenance of existing ditches and the construction of new ones for drainage purposes the construction division expended a total of $88,545.83; the new work was done in accordance with plans prepared by the sanitary department. The total amount expended for oil, and labor in its distribution, was $42,686.58.

The health conditions on the Isthmus are reported by the chief sanitary officer as an improvement over those of the preceding year. The total admissions to hospitals and sick camps, including those sick in quarters, netted for the year 26,539. The daily average of sick was 23.01 out of every thousand employed, as against 23.49 for the preceding year. The total number of deaths among employees was 548, equivalent to an average of 10.84 per thousand, based on figures obtained as follows: The average number of white employees is obtained by adding the number of white employees for each month in the year and dividing by twelve. The white employees for each month are the number of names on the gold roll for the previous month, plus all European laborers at 16 and 20 cents per hour, as appears on the first week's force report, increased by 30 per cent to cover those not actually at work, plus Panama Railroad gold employees, determined by the number of names on the gold pay rolls of the railroad company. The average number of black employees is determined by taking the number of names on the silver rolls and deducting therefrom the number of European laborers shown on the force report from the chairman's office, plus Panama Railroad silver employees, plus contractor's colored employees.

In addition to the number of deaths reported among the Americans, which aggregated 76, 39 were deported on the recommendation of the medical examining boards as physically unfitted for the Tropics, 10 were recommended for extended leave without pay for the same reasons, and 6 were given extended leave with pay in the United States on account of injuries received in line of duty.

No cases of plague or yellow fever originated on the Isthmus. One death from yellow fever, in the person of a young Englishman, occurred at Ancon Hospital on January 24, 1910. The deceased passed quarantine at Colon January 6 and was taken ill on January 8. The case was diagnosed as yellow fever on January 22. On January 24 a thorough fumigation was undertaken of the building in which the deceased lived while in Panama, as well as the factory in which he worked.

For further details concerning this department, attention is invited to Appendix P.

RECREATION FOR EMPLOYEES.

During the year a new clubhouse was erected at Gatun at a cost of $21,312.88, and a smaller hall at Porto Bello at a cost of $4,426.59. These two added to the four clubhouses already constructed at Culebra, Empire, Gorgona, and Cristobal have been under the supervision of the Young Men's Christian Association. The membership was largest in June when it reached 1,643, the average monthly

membership for the year being 1,264. The total expenditures from commission funds for the support of these clubhouses aggregated $38,812.41.

A small recreation hall was constructed at Corozal at a cost of $3,954.66, and since its completion was under the management of the employees themselves.

Further details of the operations of the clubhouses is given in Appendix Q.

WASHINGTON OFFICE.

The work of the Washington office was of the same scope as reported for the preceding year, and continued in charge of Capt. F. C. Boggs, Corps of Engineers, U. S. Army. A slight change in the organization was made for economic and administrative purposes by combining the work of the record and correspondence divisions under one head.

During the year 2,022 persons within the United States were tendered employment on the Isthmus in grades above that of laborer, of which 1,287 accepted and were appointed, covering 125 different positions.

The total amount of purchase orders placed during the year was $16,107,350.34; the most important of the purchases were castings, structural material and valves for use in the locks, amounting to $847,000; 4 steel barges; 2 tugboats; 3 launches; one 20-inch pipe line suction dredge; 1 hydraulic and dredging plant; 13 dredging, discharge, and relay pumps; 449 dump and flat cars; 10 cantilever cranes; 2 rock crushers; 8,745 tons of steel rails; 655,842 cross-ties; 32,715 piles; 30,771,744 feet of lumber; 14,742,400 pounds of dynamite and blasting powder.

Shipments of cement for use in the locks and dams, purchased under contract for 4,500,000 barrels, amounted to 904,727 barrels up to June 30.

For further details, attention is invited to Appendix R.

Diagrams showing organization in effect July 30 are appended and marked "S."

Respectfully submitted.

Geo. W. Goethals,
Colonel, Corps of Engineers, U. S. Army,
Chairman and Chief Engineer.

The Hon. J. M. Dickinson,
Secretary of War, Washington, D. C.

APPENDIX A.

REPORT OF LIEUT. COL. H. F. HODGES, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, ASSISTANT CHIEF ENGINEER, IN CHARGE OF THE FIRST DIVISION OF THE OFFICE OF THE CHIEF ENGINEER.

ISTHMIAN CANAL COMMISSION,
OFFICE OF THE CHIEF ENGINEER, FIRST DIVISION,
Culebra, Canal Zone, July 26, 1910.

SIR: I have the honor to make the following report of the operations during the fiscal year ending June 30, 1910, of the first division of the office of the chief engineer. This division is charged with the design of the locks, dams, regulating works, and accessories.

The organization of the division remains the same as stated in the last annual report, and consists of subdivisions in charge of designs as follows: (*a*) Masonry and lock structure, including valves; (*b*) lock gates and protective devices; (*c*) operating machinery; (*d*) movable dams, and (*e*) spillways.

MASONRY AND LOCK STRUCTURE.

This subdivision is under charge of Mr. L. D. Cornish, designing engineer, assisted by Mr. H. F. Tucker, designing engineer; Mr. T. E. L. Lipsey, assistant engineer, and the necessary draftsmen. Mr. E. D. Burnell, assistant engineer, was employed during part of the year.

LOCKS.

At the beginning of the last fiscal year the general designs for the upper lock at Gatun and for the single lock at Pedro Miguel had been finished. Drawings of these general designs were published in the annual report for 1909. During the year the detailed drawings needed by the working force in the field on the construction of the upper lock at Gatun and the Pedro Miguel lock have been made and issued from time to time, and the general features of the lower locks at Gatun and the lock flight at Miraflores have been adopted. These general features include the use of intermediate gates in the middle and lower locks at Gatun, but of no intermediate gates in the lower lock at Miraflores. The elevation of the coping of the locks has been fixed in such way as to secure sufficient freeboard to keep the chambers containing the gate machinery dry under all operating conditions. A thickness of floor of 3 feet for the middle lock at Gatun and of 1 foot for the lower lock at Gatun and for the Miraflores locks

has been adopted. Provision has been made at the upper and lower ends of all lock flights for the use of a caisson by means of which the sill of the movable dam and of the lower guard gates may be laid dry for examination if necessary.

APPROACH WALLS.

Massive concrete walls for the south middle wall and northeast side approach wall of Pedro Miguel have been designed and adopted and reinforced concrete walls for the northwest, southeast, and southwest approach walls in the same locality. The general type of the side approach walls is shown on drawing No. 7125. (Pl. 75.) At Miraflores locks northeast and northwest side approach walls have been adopted of reinforced concrete on piles. A study is now being made of cellular reinforced middle approach walls for the north approaches of both Pedro Miguel and Miraflores locks. At Gatun the design for the south approach, involving a center mooring wall of massive concrete for a portion of its length where it rests upon rock and of cellular reinforced concrete supported on piles for the greater part of its length where it rests upon fill, and involving, further, side approach walls and wing walls with arched openings to prevent concentrating wave action from the lake into the forebay of the locks, has been tentatively prepared but not yet submitted for approval.

It is intended that vessels shall moor against the middle wall and not against the wing walls of the locks. The middle wall, therefore, and the side approach walls, i. e., the portion of the side walls parallel to the axis of the lock, are to be provided with spring fenders of the type shown on drawing No. 7116. (Pl. 76.)

VALVES AND FIXED PARTS.

The Stoney gates and fixed irons for the Gatun and Miraflores spillways have been designed and are illustrated on drawing No. 7400. (Pl. 77.)

DRAWINGS.

In providing detailed plans for the features hereinbefore mentioned 56 drawings have been made and approved.

CONTRACTS.

On January 6, 1910, advertisement was issued by the general purchasing officer, on plans and specifications prepared by this subdivision, for 22 sets of frames for rising-stem gate valves to control the main culverts of upper Gatun and Pedro Miguel locks, 12 frames for the bulkheads for entrance from the lock chamber to the middle wall culverts, and 18 frames for the guard valves which will be used in all locks at the intakes of the side wall culverts. These frames consist essentially of all the parts, except the culvert lining, which will be embedded in the masonry prior to the installation of the valves. Owing to certain limitations in the appropriations available at the time the specifications were advertised, it was considered desirable to limit this contract, as to the main culvert valve frames, to the first two locks to be constructed, reserving the similar material for the other four locks for a later contract.

Under the advertisement mentioned, contract was made on March 2, 1910, with the Wheeling Mold and Foundry Company, of Wheeling, W. Va., and delivery of material had begun before the close of the fiscal year.

Before the beginning of the fiscal year 1910, award had been made to the Penn Bridge Company, of Beaver Falls, Pa., for the frames and the moving parts for two sets of Stoney valves, and to the Rosedale Foundry and Machine Company, of Pittsburg, Pa., for 40 cylindrical valves. Under the first contract but little of the material had been delivered up to the close of the fiscal year. The second contract was then about 90 per cent completed.

As the result of experience gained under these contracts, the designs have been modified somewhat from those shown in the last annual report, both by changing the section of certain of the parts, and by the substitution of cast iron for cast steel as the material.

Difficulty was experienced in obtaining the heavy cylindrical castings for the valves under contract with the Rosedale Foundry and Machine Company. The contractors have furnished these castings, but only after the loss of many, and the indications were clear that in future contracts a very much higher price would have to be paid for these particular parts if steel should be retained as the material. In the plans for future purchases, therefore, the design has been somewhat modified to allow the substitution of a special grade of cast iron, which it is known, will be less expensive and sufficiently strong.

The frames for the gate valves have also been designed for cast iron instead of steel.

Under the plans thus modified, specifications and drawings have been prepared for the remainder of the ironwork, fixed and movable, for the valves for the main and lateral culverts, with the exception of the movable parts of the Stoney valves. These plans and specifications have been sent to the general purchasing officer, and it is anticipated that the contract will be let at an early date. It is not the intention to purchase the movable parts of the Stoney valves until the work has made further progress, since these parts can be installed to better advantage after completion of the masonry.

CASTINGS MADE ON ISTHMUS.

In addition to the ironwork furnished from the United States, the commission's foundry and shop at Gorgona has made or fabricated, in accordance with the designs of this subdivision, the following material: Four hundred and thirty-four tons of cast-iron caisson seats, 656 tons of cast-iron valve chamber linings, and 107 tons of buffer spring-seat castings, all at a cost of $60 per ton.

Lock Gates and Protective Devices.

This subdivision has been under the immediate charge of Mr. Henry Goldmark, designing engineer, assisted by Messrs. J. Hammer, F. E. Sterns, and L. A. Mason, assistant engineers, with the necessary draftsmen. Mr. M. Nixon-Miller, assistant engineer, was employed during part of the year.

LOCK GATES.

Before the end of the fiscal year 1909, general drawings of some of the lock gates had been prepared, and a typical one was published in the last annual report. During the fiscal year just passed, the general drawings and the detailed drawings have been carried to completion. This involved the preparation of six general drawings, showing gate leaves of different heights, with the spacing of the girders, the scantling of the parts and plates, the position of the air chamber, and all the features wherein one leaf differs from another. Twenty-nine detailed drawings were finished, giving the number and arrangement of rivets, plates, and fillers, and showing where crimping, forging, and coping is to be done. They also illustrate special details such as manhole and shaft covers, ladders, pumping system, foot walks, and movable hand railings. The weights of the different parts have been calculated in detail, and specifications covering the entire work have been prepared.

On April 16, 1910, proposals were invited by the general purchasing officer for the lock gates for the entire canal. Bids were opened on June 15. The lowest bidder was the McClintic-Marshall Construction Company, of Pittsburg, Pa., whose prices were 3.785 cents per pound for structural steel erected; 2.62 cents per pound for structural steel not erected, and $5,374,474.82 for the entire work. The other bids received were from the United States Steel Products Export Company, $6,103,041.10; from the Maryland Steel Company, $8,409,369.31; and from the Riter-Conley Manufacturing Company, $10,183,257. Contract has been made with the McClintic-Marshall Construction Company, and the preliminary work is now in progress. The contract covers the erection, complete, of all the gates in the canal, 46 in number, or 92 leaves, and spare parts sufficient for the construction of one additional gate of two leaves of the larger size.

Arranged by heights the number of leaves will be as follows:

Heights.	Number of leaves.			
	Total.	Gatun.	Pedro Miguel.	Miraflores.
82 feet	4			4
79 feet	16		16	
77 feet	48	32		16
66 feet	4			4
64 feet 8 inches	8	4	4	
47 feet 4 inches	12	4	4	4
Grand total	92	40	24	28

All gates of the same height will be identical in construction, with the exception of those 47 feet 4 inches high, which have different foot walks when used as upper and lower guard gates, respectively.

The weight of the heaviest gate leaf is 1,483,700 pounds, and the total amount of material covered by the contract is 118,488,100 pounds. Were the gates to be piled end to end, one on top of the other, they would make a tower more than a mile and a quarter high.

FIXED PARTS.

At the close of the fiscal year 1909 award for those parts pertaining to the mitering gates, which are built into the masonry, such as the anchorages, sill castings, quoin castings, etc., was pending, bids having already been opened. On July 10, 1909, contract was closed with the United Engineering and Foundry Company, of Pittsburg, Pa., for furnishing these parts at various times during the two years following, and delivery is now in progress, about 60 per cent of the material for the first two locks having reached the Isthmus.

FLOATING CAISSON GATES.

Preliminary studies have been made to determine the general outline of the caissons to be used for closing the head and tail bays of the lock flights, and this work is still in hand.

CHAIN FENDERS.

As a protection to the gates in the upper and lower approaches of each lock flight, and at those other points where the destruction of a gate might open up connection between the two levels, it has been determined to introduce a guard to the gate in the form of a chain fender, which has been used for similar purposes in European locks and was described briefly in the Annual Report for 1909. Studies have been made during the last fiscal year of various types of machinery for handling this chain and for providing the necessary resistance to its paying out when struck by a vessel. Three of the most promising types have been worked up in considerable detail, and the design is now proceeding on the basis of using a hydraulic cylinder for this purpose. The design, however, has not been finally adopted and is not sufficiently complete to warrant illustration in this report.

Operating Machinery.

This subdivision has been under the direct charge of Mr. Edward Schildhauer, electrical and mechanical engineer, assisted by Mr. E. E. Lee, assistant electrical and mechanical engineer, Messrs. C. B. Larzelere, F. A. Browne, and F. C. Clark, assistant engineers, and the necessary draftsmen. Mr. M. Nixon-Miller, assistant engineer, was employed in this subdivision during part of the year.

STONEY VALVE MACHINERY.

The design of the machinery for operating the Stoney gate valves for the main culverts has been completed in detail and approved. The valves themselves were illustrated in the last annual report. The mechanism is shown on drawings Nos. 6425, 6426, and 6427. (Pls. 78, 79, and 80.) It consists especially of a single rising valve stem with its lower end connected to the valve by two pins at right angles to each other, allowing for slight movements of the valve. This stem passes vertically through a stuffing box in a horizontal water-tight bulkhead, closing the bottom of the machinery chamber, which is 32 feet below the high level of water in the lock. The upper

end of the valve stem is carried by a crosshead actuated by two vertical, revolving, nonrising screws, driven by reducing gear from the horizontal shaft through a friction cut-off coupling by a 3-phase, 220-volt, 25-cycle induction motor. The motor is provided with a solenoid brake in order that the revolving parts may be brought to rest immediately after interruption of the line current. The crosshead is guided in its vertical travel by rollers running on rails embedded in the concrete. Each revolving screw is provided with double roller bearings at its upper end, from which it is suspended, the bearing at the lower end serving simply to guide and hold the screw, the weight being carried in suspension from the top.

The crosshead which lifts the valve stem actuates also the trains of live rollers to which the valve when in action transmits the pressure of the water, and on which it rolls when lifted. These roller trains must rise with the gate, and at half its speed. To bring this about with certainty, the upper end of each roller train is connected to a vertical stem which passes through a stuffing box in the watertight bulkhead forming the bottom of the machinery chamber. This stem is raised and lowered by a chain passing over three sheaves and fastened to the crosshead, the arrangement of the sheaves being such that the velocity of one end of the chain is just one-half the velocity of the other.

The machinery is arranged for either local or remote control, and auxiliary hand apparatus is provided for closing the gate should the machinery fail when it is in the raised position.

A limit switch is proposed to cut off the current at the proper point in the travel of the crosshead, the crosshead springs allowing some latitude in the downward motion, and chocks on the guide rails stopping the crosshead in case of extreme upward travel. The friction coupling is introduced to prevent injury to the mechanism in case of such overtravel.

CYLINDRICAL VALVE MACHINERY.

During the last fiscal year the machinery for operating the cylindrical valves has been completed and approved. The valves themselves were described in the last annual report. The mechanism is shown on drawing No. 6502. (Pl. 81.) The movable drum of the valve is connected by its cylindrical stem, rising vertically through a shaft in the masonry, to the machinery placed in a recess, the bottom of which is 8 feet below the coping level. The upper end of the valve stem terminates in a tubular extension carrying a stationary nut and passing through a stuffing box closing the upper end of the vertical shaft through which the stem passes. This nut engages a nonrising revolving screw, carried in a collar with suspension bearing. The screw is turned through suitable gearing by a motor provided with solenoid brake for bringing the machinery to rest when the current is cut off. The extension to the valve stem is prevented from turning by guides in the bedplate through which it passes. The travel of the valve in either direction is stopped at the proper point by means of a limit switch. The maximum force on the suspension bearing is exerted at the breaking of the seal when the valve is first opened. No pressure is required in closing the valve, and in case of overtravel in the downward direction the screw will

rise out of the nut and slide through the thrust collar on a long feather key.

There will be 120 of these machines in the six twin locks. On account of this large number the lubrication is made as nearly automatic as possible. When the screw turns and the nut rises on it, the lower part of the screw enters a chamber in the tubular extension, below the nut, which is filled with oil; the oil displaced by the portion of the screw projecting into this chamber is forced through vertical holes in the nut into the extension of the chamber above the nut. When the motion is reversed and the valve lowered, the oil returns through the same holes into the chamber below the nut, as the latter descends on the screw.

LIMIT SWITCH.

A limit switch to govern the motion of the different machines and cut off the current at the proper moment has been designed and will be tried with the first machines purchased.

CONTRACTS.

In the six twin locks of the canal, there will be required 116 machines for Stoney valves and 120 machines for cylindrical valves. In order to try out the machinery as designed, before purchasing this large number, specifications have been prepared for two machines of each class, with the option of extending the purchase to include 46 additional machines for the Stoney gates and 38 additional machines for the cylindrical valves. If the two first machines of each class prove satisfactory, the option may be exercised to purchase the larger number, which will be sufficient for the installation at Pedro Miguel and upper Gatun locks. Bids will be asked later for the valve machinery for the remaining four locks. The specifications as drawn allow different prices to be named for the first sample machines and for the larger number upon which the option is desired.

GATE-OPERATING MACHINERY.

After studying all the best known types of machinery for moving the gates, it has appeared that none could be counted upon to prove satisfactory. The gate leaves are of so great size that more than usual care has to be exercised to regulate the force applied to the leaf in a manner approximately proportional to the resistance to its motion. The resistance is greatest when the leaf is near the two extremes of its path, i. e., when near the mitered position, or the position of rest in the recess. At these times there is the least opening through which the water, displaced by the moving gate leaf, can pass around the edges of the leaf, and there is, therefore, the greatest tendency for it to pile up behind the leaf and form a head resisting the motion. The result of the study of the problem has been, first, to give to the recess in the wall into which the leaf fits when open, such a shape as to permit free exit of the water around the miter post of the gate when near the position of rest; and, second, the adoption of a type of machinery in which the force exerted increases and the rate of motion decreases greatly near the beginning and end of the movement.

The machinery is illustrated on drawings Nos. 6206 and 6207 (Pls. 82 and 83.) The motion is imparted to the leaf by a rigid horizontal strut connected by a vertical pin to the upper girder of the gate leaf. The other end of the rigid strut is fitted to a crank pin attached to a large horizontal gear wheel near its circumference. The gear wheel is caused to turn by a pinion or pinions revolving on a vertical axis, and actuated by a motor through a suitable train of reducing gear. As the large gear wheel is turned the effect upon the strut is practically that of a crank upon a connecting rod. The force in the direction of the strut approaches infinity at the beginning and end of the stroke, at which time the motion in the same direction approaches zero. The rate of travel of the gate increases gradually from the beginning to a point just beyond the middle of the path between the recess and the miter. After passing its maximum, the rate gradually diminishes until, just at mitering, it becomes very small.

The machine is capable of exerting its greatest force on the strut at the time when the resistance is the greatest. The rate of increase of the force, however, from minimum to maximum, is much greater than the rate of increase of the resistance. It follows, therefore, that less torque will be required of the motor as the gate moves from the recess than later when the gate has attained its highest speed. The horizontal slit in the face of the lock wall in which the strut moves is placed with its lowest point about 6 inches above the highest water level in the lock. The chamber in which the large gear wheel revolves will therefore not be actually flooded, except from some accidental cause. It is nevertheless liable to be kept continually wet by the action of the waves occasioned by vessels entering or leaving the lock and by the gates in opening and closing. For this reason the chamber in which the motor operates is separated from the chamber containing the gear by a water-tight diaphragm, the motor shaft passing through a stuffing box in this diaphragm. The effect of the water on the main gear wheel and pinions will not be injurious to any great extent. There are many cases in which similar mechanism for operating the gates and valves of locks is kept continuously under water. Drainage is provided to get rid of the small amount of water entering the chamber.

LOCKING DEVICE.

It has been thought desirable to provide on the gate leaves a positive lock which will hold them together against wave action, and at the same time it has seemed possible to combine with this lock a device which will tend to force the gates to meet perfectly at the miter and will thus reduce the care which is usually necessary in closing large lock gates to prevent a false miter. The device which will be tried for this purpose is shown on drawing No. 6208. (Pl. 84.) A crosshead is mounted at the top of the miter post of one of the leaves and is constrained to move in a horizontal plane by a screw, the direction of which is perpendicular to the plane in which the faces of the miter posts meet. As the screw is turned and the crosshead moves toward the meeting face, two jaws connected with it by toggle links are forced to close, grasping between them a pin which occupies a position on the opposite leaf such that, when it is firmly held by the jaws and the latter completely closed, the leaves

must be in perfect miter at the top. The motor which actuates the crosshead is of considerable power and the grip of the jaws is designed to be sufficient to force the leaves into perfect contact. The device is a new one and will be tried carefully before being extensively applied.

MACHINERY FOR SPILLWAY GATES.

The general plan of the machinery to be used in raising and lowering the Stoney crest gates on the spillways has been prepared and is shown on drawing No. 6706. (Pl. 92.) It will be mounted in a tunnel in the main body of the spillway dam, each gate having its separate motor and counterweights. The object of placing the machinery in the tunnel is to protect the parts of the machinery and the counterweights, and at the same time to obviate the installation of cumbersome and heavy material on the footbridge, which extends over the gates.

Briefly described, the machinery is as follows: Two chains pass vertically, one from each end of the gate, over sheaves mounted immediately beneath the footway at the masonry piers between which the gate rises and falls. After passing over the sheave the descending branch of the chain is made fast to a screw, from the lower end of which hangs a counterweight. Between the end of the chain and the counterweight the screw passes through a revolving nut which forms the hub of a worm wheel; the worm wheel is equipped with double thrust bearings and is capable of taking a vertical thrust in either direction. The two worm wheels, one for each end chain, are actuated, one by a right and one by a left worm, the worms forming the ends of the shaft of a motor placed in the tunnel, and in the plane of the middle of the gate which it operates. As the motor turns, both the worm wheels revolve, causing the corresponding vertical screws to travel both in the same direction and at exactly the same rate, thus raising or lowering the gate. The screws themselves can not turn, being held by the counterweights, which travel in guides. The effect of the counterweights is, of course, to diminish the power necessary to move the gate. The gate itself is 46 by 19 feet, and weighs approximately 43 tons. As the head under which the gates operate may reach 18 feet, trains of live rollers are provided to diminish the friction against the side castings. On these roller trains the gate rolls in its up-and-down travel, the trains moving at the same time in the same direction as the gate and with half its speed. The roller trains are suspended by a chain passing around a sheave, the dead end of the chain being fastened to the pier near its top and the live end to the gate itself. When the gate is raised and the water rushes under its lower edge, it is thought desirable to have means of hoisting the roller trains out of the current, as otherwise they would remain projecting for about one-half their length below the lower edge of the gate, and might be injured by drift or floating obstructions. For this purpose a device for moving the roller train at a more rapid rate near the end of the travel of the gate has been designed. It consists of a pair of sheaves placed near the top of the gate, around which the chain of the roller train passes, both sheaves remaining fixed until the bottom of the gate is above water and frictional resistance eliminated. The gate is then guided upstream by two pairs of guide wheels so that the roller train is freed

from contact with the downstream face of the gate. At this point in the upward travel the lower sheave engages and is held by a bracket in the masonry pier while the upper one continues to rise with the gate. The chain between the sheaves is therefore drawn out and the speed of motion of the roller train correspondingly increased, so that at the end of the travel the bottom of the gate and the bottom of the roller train will be at the same elevation and the train will be protected from accident.

TOWING DEVICES.

The study of the method of moving the vessels into and out of the locks has been continued during the year, and a design has been drawn up for an electric locomotive which it is thought will do the work satisfactorily. The design, as at present adopted, is shown on drawing No. 6806 (Pl. 85), which gives a general view of the machine, for which the detailed drawings are now being made.

It is the intention to tow vessels through the locks, using a number of these locomotives, varying with the size of the vessel; the typical case requiring four locomotives, two ahead, one on each wall, imparting motion to the vessel, and two astern, one on each wall, to aid in keeping the vessel in a central position and to bring it to rest when entirely within the lock chamber. When passing the vessels up through the locks, while the water levels are being equalized, the forward locomotives will advance up the incline of the lock walls to the level of the next lock chamber and will not be required to exert towing effort while on these inclines. As will be seen from the drawing, the electric locomotive consists of three distinct elements. Two of these, the front and rear elements, are mounted upon rigid four-wheel trucks, each one of which is driven by an independent motor controlled from either end of the machinery. The third element is connected with the tractive elements by universal joints and is equipped with a slip drum towing windlass and hawser. The line can, therefore, be taken in or paid out by the windlass, thus permitting varying the distance between the ship and locomotive, and a pull can be exerted or relieved without actual motion of the locomotive on the track. The ability to do this is eminently desirable, especially in bringing the vessel to rest or in changing the length of the towline, as, for instance, when the locomotive ascends the incline to the next lock, while the levels in the two locks are equalizing and the vessel necessarily stationary. For general purposes, however, in towing, the locomotive derives its tractive effort from one of the end elements, through a pinion engaging a shrouded semisuppressed rack anchored in the coping. The side pull of the towing line is taken up by horizontal thrust wheels, which bear on the side of the track.

Each flight of locks will be provided with two towing tracks, one on the side and one on the middle wall. On each side wall there will be one return track and on the middle wall a third, common to both of the two twin locks. All tracks will run continuously the entire length of the respective flights and will extend some distance on the guide and approach walls at each end. At the termination they will be joined by a switch. The current for the operation of the locomotives will be taken from underground conduits. The

maximum pull on the towline is fixed at 25,000 pounds, at which force a friction coupling will relieve further strain. The central racks are provided only on the towing tracks and inclines. On the level portion of the return tracks the locomotive is driven by friction on the side rails.

MACHINERY FOR WICKETS AND GIRDERS OF MOVABLE DAMS.

Studies have been made for raising and lowering the wicket girders and wickets of the movable dams, and the general plan will soon be ready for action.

LAYOUT OF CIRCUITS.

Much study has been given to the method and arrangement of the light, power, signal, and control circuits for operating the locks. A tentative general method and scheme has been presented, and certain of the details which affect the masonry now under construction have been approved. The system is so extensive, however, that it is desired to give further study to the general plan before its final adoption. The features already provided include a continuous tunnel running the full length of each wall with a continuous conduit space below its floor. Connections between the walls of the locks are obtained through vertical cable shafts and tunnels under the lock floors. All cable manholes and junction boxes, as well as all stationary machines and transformers or power centers will be on the level of the floor of this tunnel and accessible from it. Drawing No. 6115 (Pl. 86) gives an idea of the number of machines. The adoption of the tunnel with concealed conduit space permits placing the machines below the coping level while still retaining easy communication with all of them. It thus leaves the coping free from machines and other obstructions, reduces to a minimum the number of manholes in the coping and avoids tearing up the masonry in the future if additional duct space should be required. Below the conduit space in the operating tunnel is a drainage tunnel. The general scheme of the control and interlocking system has been studied during the year, but is not yet complete. The basic idea, however, is to operate all the gates and valves and other apparatus from one central point, this point to be a tower situated on the wall between the twin locks and probably at the lower end of the upper lock in each flight. The operating room will be provided with indicators showing the position of each one of the machines, and the water levels in each one of the pools under its control. It is intended so to interlock the system that the operations must take place in the proper sequence.

GENERATING STATIONS.

During the year two steam electric-generating stations to furnish power had been completed and placed in operation, one at Gatun and one at Miraflores. The steam and turbine equipment of the two are identical. The electrical equipment is also identical, but the converters are installed in different positions at Miraflores from those which they occupy at Gatun. At each station the generator room contains three 1,500 k. v. a., 3-phase, 2,200-volt, 25-cycle, steam-tur-

bine base condenser generators, provided with steam by six 400-horsepower water-tube boilers, arranged in batteries of two each. At Gatun the substation equipment, consisting of two 500-kilowatt and one 300-kilowatt, 500-volt rotary converters, is located in the turbine room. At Miraflores only the 300-volt converter is placed in the central station, the two 500-volt converters being temporarily in a field station. The boilers use fuel oil, the supply system being installed in duplicate.

MISCELLANEOUS.

Considerable time has been given to the study of freight handling at Balboa wharf, plans for which were embodied in a report by a committee appointed by the chairman.

Designs have been made of a cement unloader to be used at Colon by the Panama Railroad Company. One of the machines is being built in the shops at Gorgona and will soon be ready for operation. This design was made in connection with the report of a committee appointed by the chairman.

Movable Dams.

This subdivision is under the immediate charge of Mr. T. B. Monniche, designing engineer, assisted by Mr. C. Derrick and Mr. F. H. Moore, assistant engineers, and the necessary draftsmen.

DAMS AT GATUN AND PEDRO MIGUEL.

Before the beginning of the fiscal year the preliminary design of the movable dams, as illustrated in the last annual report, had been prepared. During the last fiscal year studies and lay-out plans of the details have been completed, and the final contract drawings of the structural work and the turning and wedging machinery have made such progress that it is hoped to advertise the work within a few months. Sixty-one final contract drawings have been made during the year, and a draft of the specifications for the structural work and the turning and wedging machinery have been prepared. The general plan of the movable dams for Gatun and Pedro Miguel locks is illustrated in drawing No. 5504. (Pl. 87.)

The structural work for each dam may be conveniently divided into the following units: Vertical trusses, horizontal truss, wicket girders, and rolling gates, with the necessary bracing between the same.

The vertical trusses are of the cantilever type, with unequal arms. The long arm carries the parts which form the dam proper, while the short arm supports the counterweight. The general outline of the truss on the long arm is determined by the requirements of the parts which it supports. The elevation of the floor is fixed by the clearance required for storing the gates in a vertical position between the floor beams and wicket girders. The proper slope of the ties which support the booms gives the minimum height of the top chord above the floor, and, as this provides sufficient depth of truss for the portion which spans the lock, the chord is made horizontal over that distance and a variable depth of truss obtained by sloping the bottom chord, beginning at a point immediately beneath the floor. The panel

lengths for this part of the span being limited by the spacing of the wicket girders, subpanels are introduced and the Warren system of bracing, with riveted members and connections, is used. The vertical posts of this system are submembers, and can therefore be made alike, simplifying all members connecting to the same. Eye bars are used for the top chord members over the center portion of the truss and continued to the far end of the counterweight arm. The slopes of the bars on either side of the center post are different, and so chosen that the reactions on the two center cross girders will be equal.

The horizontal truss is of the Warren type with subdivided panels and riveted joints throughout. It carries no load before the dam is in place, being supported at frequent intervals to the overhanging booms. At each panel point of the compression chord is a bracket, braced in horizontal and vertical planes, in which the upper ends of the wicket girders fit and are pivoted on horizontal pins.

The wicket girders are adapted to resist torsion, side forces, or rough usage of any character to which they might be subjected while lowering into a swift current. They are of box section, the two webs being rigidly connected by channel stiffeners, and present a smooth outside surface to the water, with a minimum exposed area to the same. Large holes in both webs provide drainage and access for painting the interior surfaces. The girders are connected in pairs by a system of lateral bracing in the plane of the top flange. This bracing presents only a small area to the current and is omitted in the lower panel. The lower ends permit of considerable vertical motion relative to each other, which might be required in the event of striking some obstruction in the pockets or of unequal action of the lowering tackle attached to each girder. The crane rail, which is riveted directly on the top flange, carries its proportion of the flange stress and transfers the loads from the wheels of the rolling gates into the girders without eccentricity and secondary stresses.

The rolling gates are frames consisting of structural beams covered with buckle plates and supported by flanged wheels turning on roller bearings. When these wheels are brought in position on the top flange of the wicket girders, **Z**-bar guides engage under the outer side of the head of each rail and prevent uplift of the gates, while the flanges of the wheels prevent lateral displacement. The upper and lower edges of each gate are wedge shaped and formed by a bent plate filled with concrete. The bevel of adjacent edges being in the same direction, they can be brought to a close contact when the gates are in final position, and prevent any tendency of the ends to spring out from the rails. Great care has been used to reduce friction and the possibility of binding or sticking as the gates are being lowered against pressure. If, however, they should stick from unforeseen causes, it is thought that a pressure brought to bear on the upper edge of the topmost gate, with the aid of the interlocking noses mentioned above, would be more effective than any device for pulling them down. The weight of one gate free from water pressure would always be available for this purpose, and moderate blows or weights on the upper edge should be effective. The vertical apertures between the sets of gates which were provided for clearance while handling them can be closed by forcing down drivepipes in the grooved edges of adjacent gates.

To reduce the weight on the center pivot and to reduce the sections of structural members to medium thicknesses, it is proposed to make the vertical trusses, horizontal truss, and wicket girders of nickel steel. The gates and bracing connecting the other units of the dam are to be of carbon steel.

The general plans of the turning and wedging machinery are shown in drawings Nos. 5529, 5531, 5534, and 5535. (Pls. 88, 89, 90, and 91.)

Before any attempt can be made to turn the dam, it must be balanced about its center pivot while swinging. Balance of the structure about its longitudinal axis will be attained by placing the machinery for operating the wicket girders and that for operating the gates as near their proper location in regard to this axis as practicable and then shifting the gates on the floor beams. A large concrete block at the extreme end of the short arm gives transverse balance. This block is provided with pockets and the final adjustment will be made by placing a proper amount of pig iron in these pockets. In order to reduce the size of the concrete block and the load on the center pivot the turning machinery is located at the extreme end of the short arm, thus forming a part of the counterweight.

The whole structure is turned about its center pivot by means of two main pinions that are geared with a rack quadrant. These pinions are connected to two motors by two separate trains of spur gears and one equalizer gear, the latter being directly in mesh with the motor pinions.

On account of the great resistances to be overcome in turning the structure, and in order to reduce the force required for performing this work, and the size of the two main pinions, the radius of the rack quadrant has been made as large as conditions will allow.

The two main pinions are shrouded on their upper sides and the teeth are of special design in order to increase their strength. The equalizer gear serves the purpose of equalizing the tooth pressure of the main pinions upon the rack due to imperfection in size of the teeth of the rack.

The two motors for turning the dam have each a capacity of 112 horsepower. They are reversible, open motors, furnished with solenoid brakes. Each motor can be operated by its own controller and is so connected that either controller can be used to operate either or both motors. Ordinarily both motors will be used in turning the dam, but each will be of sufficient capacity to turn the dam independently. A limit switch is connected to the motors to cut off the current when the end of the long arm of the dam is near the closed position. The exact position of the dam while turning is shown on an indicator located in the operating house. An air buffer has been bolted to the horizontal truss at the extreme end of the long arm to take any shock as the structure is brought to rest after turning.

In order to secure solid bearings for the structure while at rest, and while operating wicket girders and gates, provision has been made for one pair of wedges at center and at each end. All wedges are driven simultaneously by one 25-horsepower closed motor, located at center directly under the floor. This motor is controlled from the operating house where also the wedge indicator is located.

The separate machines for driving each pair of wedges are located at the center and at both ends, respectively. Each machine consists

of one worm and one worm gear, the latter connected to two separate trains of spur gears, each driving one wedge by means of a double toggle joint. The machines at both ends are connected to the motor by a line shaft and by one reduction of spur gears.

For the purpose of centering and of locking the dam while in closed or in open position, the dam has been provided with an end latch at the long arm. This latch is operated in accordance with ordinary drawbridge practice simultaneously with driving or releasing wedges.

Electric current will ordinarily be used to operate all machinery located on the dam and will be obtained from underground cables coming to the surface at the center casting; but in all cases provision is made for hand power. All motors and electrical equipments have been designed for alternating current, 25-cycle, 3-phase, and 220 volts, delivered at the switchboard.

DAM AT MIRAFLORES.

Owing to the fact that the level of Miraflores Lake is practically stationary, while that of Gatun may vary within considerable limits, the depth of water in the forebay in the Miraflores Lake is 8 feet less than the maximum depth in the forebays at Gatun and Pedro Miguel. It follows that it has been necessary to prepare a special design for the Miraflores movable dam, owing to the shorter length of the wicket girders which it will carry. Before being able to prepare this design careful investigations had to be made of the balance of the dam with respect to its longitudinal axis when swinging. As a result of these investigations it has been found possible to duplicate many features of the Gatun and Pedro Miguel dams at Miraflores, using, however, shorter wicket girders and four sets of lowering gates instead of five, reducing also the width of the horizontal truss to correspond with the shortened wicket girders and reducing the section of the members of the vertical trusses.

SPILLWAYS.

This subdivision is under charge of Mr. E. C. Sherman, designing engineer, with two draftsmen.

The spillway dams to be built will be two in number—one at Gatun, capable of passing the maximum continued discharge of the Chagres River, estimated at 137,500 cubic foot-seconds, and the other at Miraflores, capable of passing the estimated discharge from the Gatun Lake level through one of the twin locks at Pedro Miguel should the gates of the latter be carried completely away. The discharge is estimated at 90,000 cubic foot-seconds.

GATUN SPILLWAY.

The largest known flood discharge of the Chagres River into Gatun Lake would render necessary a very long spillway were the latter designed to maintain the adopted lake level with uncontrolled overfall. It is calculated that even were the crest to be 2,000 feet long the lake would rise 5 feet in an extreme flood. Owing to the undesirable features, among them the great cost of such an installation, it has from the first been thought necessary to control the lake by a weir with crest gates, permitting a greater depth and consequently a greater volume of flow than can be given by an uncontrolled crest of

the same length. The general design, shown on drawings Nos. 4019 and 4020 (Pls. 93 and 94), which has been adopted for the Gatun spillway, obtains the necessary development of crest by throwing the trace of the dam into a circular arc. By this form the discharge is directed toward the center, where the energy of the converging stream will partially neutralize itself. To complete the neutralization, two rows of baffle piers are to be placed on arcs of circles concentric with the crest of the dam, the upper one being about 140 feet below the crest. These baffle piers are to be of concrete, faced on the upstream side with cast-iron plates, and project about 10 feet above the surface of the apron. The dam has what is commonly called an "ogee section," made up of a parabola, a short tangent, and an arc of a circle leading to the flat apron below the dam. The parabola is such that when the stream of water flowing over the crest is 6 feet or more in thickness the nappe will adhere to the downstream face of the dam. The crest of the dam is divided into fourteen bays 45 feet wide by thirteen piers and the two abutments. Between consecutive piers Stoney gates will be placed, rising on trains of live rollers, which move on castings set in grooves in the piers. These gates are illustrated in drawing No. 7400 (Pl. 77), accompanying the report of the masonry subdivision of this office. The sill of the gates, which forms the crest of the fixed part of the dam, is at elevation +69, or 16 feet below the normal level of the lake, which is assumed at +85. The highest level to which it is intended to allow the lake to rise is +87, and at this level it will probably be maintained continuously throughout the wet season in future years when the traffic shall require the maximum possibilities. It is not intended to allow it to rise above +87 at Gatun. It is, nevertheless, possible that sudden floods in the Chagres coming at a time when the lake is at its high level may produce levels somewhat higher by backing up in the Culebra cut. The effect of such a moderate increase, up to, say, +90, would not be serious, but might flood the machinery pits of the upper gate-operating mechanism at the Pedro Miguel lock. The machines would work well enough when under water, and the conditions would be only temporary.

With lake at elevation +87, one bay of the crest gates when fully opened will discharge about 11,000 cubic foot-seconds, and all fourteen will therefore discharge about 154,000 cubic foot-seconds. This is more than the maximum known discharge of the Chagres River continued during a period of thirty-three hours, which is 137,500 cubic foot-seconds at Gatun. As a reserve, there are available the lock culverts at Gatun and Pedro Miguel, which together would discharge about 40,000 cubic foot-seconds at the same lake level.

Since the coping and the top of the gates at upper Gatun and Pedro Miguel locks have been placed at +92, it would require a rise of 5 feet in Gatun lake, above +87, to do material damage. It would take the maximum continued discharge of 137,500 cubic foot-seconds nine hours and twenty minutes to raise the level of the lake 1 foot, from +87 to +88, even were no gates of the spillway to be open during this time.

The maximum momentary discharge of the Chagres River at Gatun is calculated from the measured Bohio discharge, to be 182,000 cubic feet per second. Were it possible for the lake to reach the level of +92, when it would first become dangerous, the spillway alone, if fully opened, would discharge at the rate of 222,000 cubic

feet per second, without counting the reserve discharge capacity of the lock culverts. It is apparent, therefore, that the means provided are ample to hold control of any possible flood, and even to allow for negligence and delay in operation.

When the gates of the spillway are fully raised, the bottom is at elevation +92. As the surface of the water must acquire a considerable slope before passing under the gate, there will be, with the main lake surface at +87, a distance of about 7 feet between the surface of the flowing water and the lowest element of the gate. This space is considered sufficient to allow the passage of any drift which is to be expected at the dam. Precautions may have to be taken in the lake above to prevent the run of heavy drift. However, inasmuch, as the lake will be very large, and the current in it extremely gentle, it is believed that most drift coming down from the upper Chagres or originating in the lake area will be stranded before it reaches the dam, or at the worst will approach in such small quantity and at such low velocity that it can be readily handled by small tugs operating above the dam. For these reasons no special provisions for passing drift have been made in the design.

As it is necessary to use the spillway channel as a weir, for the escape of the Chagres River during the construction of the main dam across its natural channels, the construction of the body of the spillway dam will be one of the last parts of the work to be completed, and special means will have to be provided to permit its construction in the face of the water rising in Gatun Lake. During the past fiscal year the foundation of the dam has been placed at elevation +10, and the other channels have been shut off. The river discharge is now going through the spillway, the lake having been backed up by the foundations of the dam so that its surface now stands at from 16 to 20 feet above sea-level. At the place, therefore, where the body of the spillway dam will eventually have to be placed, there is now a rushing river which in the wet season carries an average of about 10,000 cubic foot-seconds, and in the dry season an average of about 3,000 cubic foot-seconds. To permit shutting off the water when it is desired to construct this main dam, piers have been built projecting upward above low water from the foundation, on the site of the upstream face, and about 20 feet apart. Between these piers stop plank can be placed and the concrete laid behind the protection of the coffer-dam thus formed. In the meanwhile, the first operation will be the installation of four low level culverts, three of them regulated by Stoney valves, and the fourth by a cylindrical valve, all exactly like those to be used in the locks. These culverts will be installed probably during the next dry season. To permit their installation and the subsequent recovery of the movable parts, it has been necessary to make the three main piers under which they are to be placed wider than the others on the crest of the dam. The location of these wider piers is central and will be noted on drawing No. 4019. (Pl. 93.) By the aid of these culverts the lake level can be regulated during the construction of the remainder of the spillway dam, and the concrete can readily be kept ahead of the slowly rising lake surface. Finally, when all the crest gates except those between the three large piers have been installed, the movable parts of the valves in the low-level culverts will be removed under the shelter of stop logs placed at the openings of the culverts, and the culverts

will then be filled with concrete. The remaining crest gates will be installed under the shelter of caissons placed between the piers above their grooves, and the flow will thereafter take place over the crest of the dam.

During the past year the walls of the approach channel to the spillway have been designed, the general drawings of the work prepared, the details of the piers and abutments drawn, and layout made of the low-level culvert gates and operating machinery for temporary lake regulation; and designs made of the metal work to be built into the masonry. A total of thirty detail drawings have been prepared, necessitating many calculations, studies, and estimates.

MODEL.

In order to ascertain, as well as might be without great expense, the behavior of the water when flowing over a weir of this space and section, a model to a scale of one-thirty-second was constructed and placed where a discharge of reasonably constant volume could be assured. The effect of the baffle piers in checking the energy of the water, and the rise of the waves on the channel walls, as shown by the model, correspond very closely to the figures which calculations had previously given. It is recognized, however, that the effect of the small volume of water flowing over the small scale model is not a reliable indication of the effect of the enormous volume which will flow over the Gatun spillway at high lake level. The behavior of the baffle piers when exposed to the full flow is a matter which will be most interesting, and about which doubts may be entertained. Two photographs accompanying this report illustrate the model under full discharge. (Pls. 1 and 2.)

MIRAFLORES SPILLWAY.

As stated above, the Miraflores spillway will be designed to pass about 90,000 cubic foot-seconds instead of the comparatively insignificant amount which flows into the Miraflores lake from the watershed tributary to it. For obvious reasons it has been thought desirable to use exactly the same gates and other details at Miraflores as at Gatun. Owing, however, to the smaller discharge requirements, the development of crest will not be so great, and it will undoubtedly be found practicable, in the space available, to lay out the dam with a straight crest. A general plan has been prepared and is now under consideration, but, owing to the fact that certain of its features have not yet been definitely fixed, no illustration of it accompanies this report.

ACCESSORY PARTS.

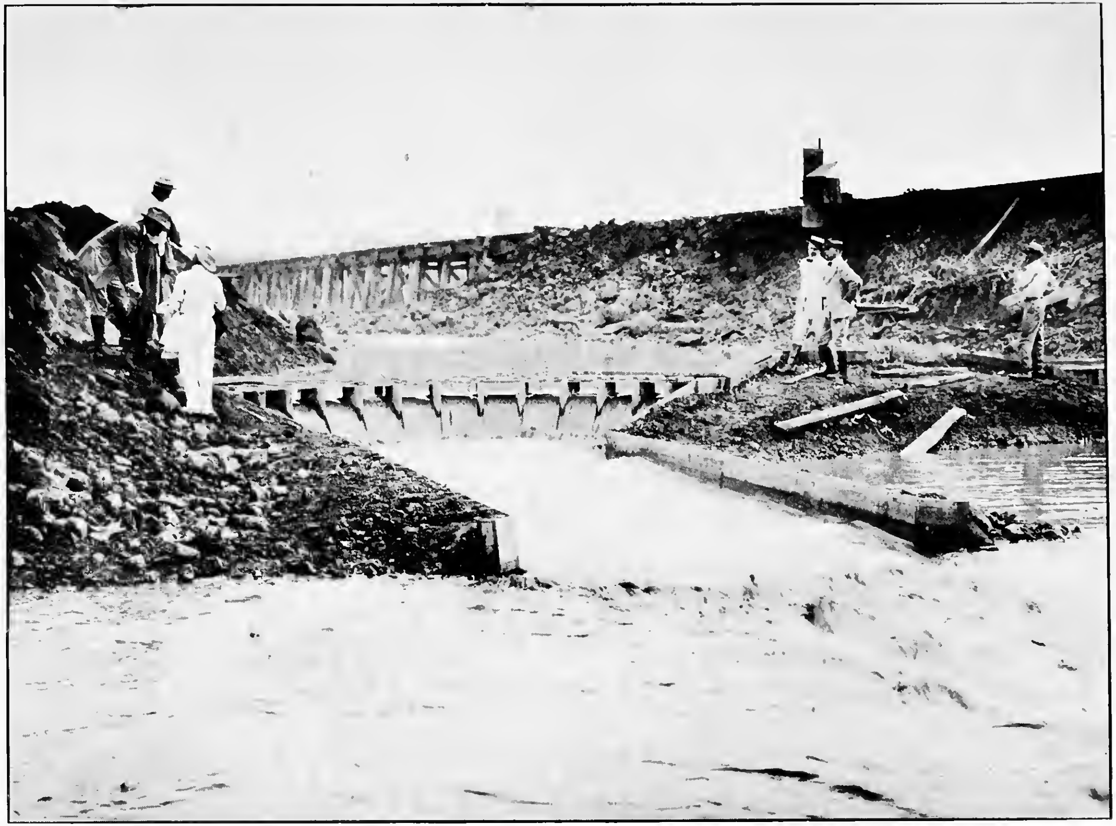
Detailed drawings have been begun for the steel footbridges for the two spillways and for the caissons, seats for which have been provided in the design of the piers. These caissons will enable a single bay of the spillway to be coffered off for installation, painting, or repair of the gate.

Respectfully submitted.

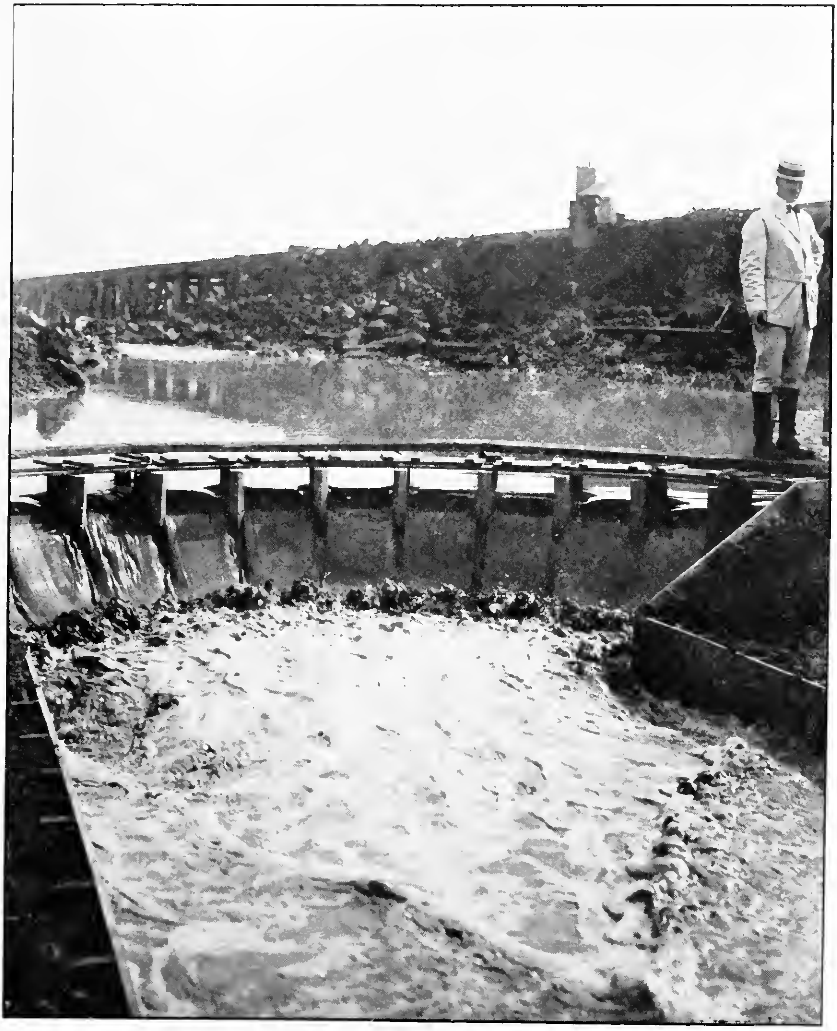
H. F. Hodges,
Assistant Chief Engineer.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.

PLATE 1.



MODEL OF GATUN SPILLWAY USED FOR EXPERIMENTS. SCALE 1:32. FEBRUARY, 1910.



MODEL OF GATUN SPILLWAY. VELOCITY OF WATER CHECKED BY BAFFLES BELOW SPILLWAY DAM. FEBRUARY, 1910.

APPENDIX B.

REPORT OF LIEUT. COL. H. F. HODGES, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, ASSISTANT CHIEF ENGINEER, IN CHARGE OF THE FIRST DIVISION OF THE OFFICE OF THE CHIEF ENGINEER, RELATIVE TO THE ADVISABILITY OF USING INTERMEDIATE GATES IN THE LOCKS OF THE PANAMA CANAL.

Isthmian Canal Commission,
Office of the Chief Engineer, First Division,
Culebra, Canal Zone, August 15, 1910.

Sir: In arriving at a final decision as to the advisability of using intermediate gates in the locks of the Panama Canal, it has been necessary to give extended study to the water levels, lifts, and critical depths in the locks which would result from using chambers of different sizes. I have the honor to submit the results of this study, which form the basis for certain features of the design adopted for the locks. In an appendix will be found the calculations on which the results are founded.

It will be remembered that in the present design the upper locks at Gatun and at Miraflores and the lock at Pedro Miguel have, in each of the twin chambers, two gates at the head, two gates at the foot, and an intermediate gate separating the chambers into two parts. The intermediate gate is also introduced in the lower locks of the Gatun flight, but is not present in the lower Miraflores lock.

The drawing, No. 5001 (Pl. 95), accompanying shows the dimensions of the chambers available between the different gates as limited by the fender chains and the quoins above. The drawing also shows that the lower locks differ in length from the upper locks, owing to the fact that the extra pairs of gates and the fender chains are not provided except in the upper locks, the guiding principle having been to guard specially only the approaches of the system and those interior points where an accident may lead to a connection between the water levels above and below. With the present arrangement, all such vital points will be thus guarded. At other points, collision with the gates, while it may result in serious damage to the latter, can not mean danger to the whole structure of the locks. It has been considered that the duplication of the locks provides adequate relief for conditions that would arise from such local damage and no additional protection has been introduced at such nonvital points.

It results, from the adoption of this principle, that the upper lock is longer than the lower ones in the same flight, and its area in plan is correspondingly greater; consequently, when it is emptied into the one next below, the water levels will equalize, not at the plane midway between the two original levels, but at a plane somewhat higher, the elevation of this plane being a function of the relation between the areas of the locks.

LOCK FLIGHT AT GATUN.

In the appendix it is shown that with the lake at +85 and the sea at 0, the lifts in the flight of the 1,000-foot locks at Gatun are 26.44 feet from the upper to the middle lock, 29.28 feet from the middle to the lower lock, and 29.28 feet from the lower lock to the sea. The area of the upper 1,000-foot lock being 134,000 square feet, the prism taken from the upper level when the full length is used is 3,543,000 cubic feet. This prism is taken as the normal prism of lift for the 1,000-foot locks of the Gatun flight. Considering lake ranges between +87 and +82, the maximum prism of lift is found with the lake at +87 and the sea at −1, when the lift from the upper to the middle lock is 27.38 feet. The smallest prism of lift is found with the lake at +82 and the sea at +1, when the lift is 25.20 feet between the upper and middle lock. When the lake is at +82 and the sea at −1, the least draft is 41.18 feet. If the lake level should be allowed to drop to +80, the minimum depth at low tide would be 39.80 feet.

The above data refer to the 1,000-foot lock only; that is, to the prism used when locking with the lower pair of upper gates open and a large ship lying with its stern in the space between the two pairs of upper gates and its stem close to the fender chain above the lower gates. This will be necessary only in downbound lockages of the largest vessels which can be passed, since in the upstream lockages of similar craft the space between the lower gates and the fender chain is available, and both pairs of upper gates can be kept closed. It is therefore only in case of the downstream lockages, in passing one of the largest possible vessels, that what we may term the "1,000-foot lock," requiring the largest prism of lift, need be used. At other times, both for all lockages of vessels not more than 900 feet long and for upstream lockages of the largest vessels, both pairs of upper gates may be kept closed, and what may be termed the "900-foot lock" may be called into play. In this case the area of the upper lock is 123,000 square feet, the area of the lower locks remaining as before. The normal lift, with the lake at +85 and the sea at 0, is 28.02 feet from the upper to the middle lock; 28.49 feet from the middle to the lower lock; and 28.49 feet from the lower lock to the sea. The lockage prism under these conditions is 3,446,000 cubic feet. The minimum draft, with the lake at +82 and sea at −1, is 39.64 feet over the lower sill of the upper lock. With lake at +80 and sea at −1, it is 38.30 feet. With the lake at +85 and sea at 0, the critical depth is 41.98 feet. It should be remembered that this depth occurs at the lower sill of the upper or middle lock and can be increased at pleasure by drawing more water from the upper level.

The assumption is made that in the operation of the locks as designed it will take a large vessel about one-half an hour to complete a lockage, i. e., to enter the lock, be raised or lowered to the next level, and then to have the gates opened and pass out. If this be correct, the minimum interval between consecutive ships at either of the lock flights will be one hour, and the maximum possible number of lockages per day will be 24 in each direction, i. e., 48 complete passages per diem.

The water supply available for Gatun Lake is sufficient during the wet season, or for about eight months of the year, for a traffic very much greater than time will allow, and during the four months' dry season of average discharge there will also be an ample supply of water, no matter how great the traffic may become. It has, however, been questioned whether, during seasons of exceptional dryness, there may not, for pa-t of the time, be a scarcity of water for lockages. For this reason, as well as to hasten in some degree the rapidity of lockage, it has been thought desirable to incorporate into the design certain features permitting economy of water when necessary.

Before presenting the following description of these features of the design, I wish to express the opinion that their use, purely for saving water, will not be necessary for many years and possibly never; first, because the water supply will be sufficient for any traffic except in most unfavorable seasons, which occur only rarely, and, second, because even in such exceptional seasons economy of water will be necessary only with a traffic so large that it is not reasonably to be expected for a long time, if at all. Nevertheless, convenience may dictate the use of these features of the design even when no reason exists for economizing water.

In the report of the board of consulting engineers of 1905, page 75, it is stated that at Gatun, where there are three locks in a flight, intermediate gates would be omitted, as they would not furnish the same advantage in saving water as they would at the other locks. After the report of the board was rendered, General Abbot, in talking the matter over with the writer, stated that saving could be made by using intermediate gates in the three-lift flight, and he was right. In the appendix will be found a discussion and demonstration of this fact. The analysis of the situation proves that, with locks divided as proposed into chambers having 350 and 550 feet of useful length, a saving of about one-third of the lockage water can always be made, without loss in depth, by using the 550-foot chamber for downbound vessels, and that an interruption of the series of 550-foot downlockages, by the arrival of a vessel requiring a larger lock, nullifies none of the saving already made. In upbound lockages the 550-foot lock can also be used with similar saving and without loss of draft. If, however, the series of 550-foot lockages going upstream be interrupted by the use of the larger locks, a part or the whole of the saving due to one of the previous lockages may be nullified. If the vessel causing the interruption draws less than 37.35 feet, it can be passed at the normal stage by drawing from the upper pool a prism only slightly greater than would be drawn in an ordinary large lockage, and only about 30 per cent of the saving due to one of the previous 550-foot uplockages would thus be nullified. If, however, the vessel is of such a size as to require the complete restoration of levels in the flight before it can be passed, then each such interruption of the series of uplockages would practically nullify the saving due to one of the previous 550-foot lockages. It is evident, however, that such an interruption would be very rare. When it happens it would not occasion loss of water, but would only wipe out part of a saving already made.

The area of the upper 550-foot lock in the Gatun flight is 82,500 square feet, and the areas of the two lower 550-foot locks are 80,500

square feet. For the normal conditions with lake at +85 and sea at 0, the lift of the upper lock is 27.88 feet, and of the two lower locks 28.56 feet. The prism of lift under these conditions is, say, 2,300,000 cubic feet, and the least draft under the same conditions is 42.12 feet. The water used is therefore only 67 per cent of that used in the 1,000-foot lockage, or 70 per cent of that used in the 900-foot lockage. The least draft, with the lake at +82 and the sea at −1, is 39.76 feet, and with the lake at +80 and sea at −1, it is 38.42 feet. The 350-foot lock may also be used to advantage for a considerable number of vessels. There is always a saving in using this lock for downbound vessels, the amount of water used being less than that for a 550-foot lockage, even though the flight be made ready immediately afterwards for a larger boat. There is no gain and no loss in using the 350-foot lock for a single upbound vessel followed immediately by one requiring a larger lock. If two or more small vessels upbound follow each other, there is a considerable saving of water by using the 350-foot lock. It should be noted that with a fender chain above the intermediate gates in the upper lock it is possible to pass vessels of length up to 358 feet bound upstream by using only the chamber between the intermediate gates and the lower set of upper gates, while to pass vessels between 278 and 358 feet long, going downstream it would be necessary to leave the lower set of upper gates open, letting the stern project into the space between the lower and upper set of upper gates. In this way the upbound lockage for the 350-foot lock takes less water than does the downbound lockage, in case of the largest vessels which are capable of using this lock. As will be seen in the appendix, the theoretical prism of lift—i. e., the prism which would result from a long series of small vessels following each other—is only 804,000 cubic feet, and the reasonably probable average prism at mean stage is 1,181,000 cubic feet, or about 30 per cent of the 1,000-foot lockage prism, and about 58 per cent of the 550-foot lockage prism. It is seen, therefore, that the presence of the intermediate gates in the Gatun flight makes possible a considerable saving in water without corresponding reduction in draft.

There is still another method of saving available, due to that feature of the design of the locks which permits passing water from one lock to its twin through the middle wall. The analysis given in the appendix proves that at Gatun there is a possible saving, due to this maneuver, of 24 per cent, with a limiting depth of 29.66 feet at normal levels, and that a saving of 8 per cent can practically always be made in the 1,000-foot locks with a least depth at normal levels of 34.45 feet. A similar percentage of saving can be effected by cross filling the 550-foot locks, the critical depths being about the same, while saving can also be effected by a similar maneuver in the 350-foot lock. As explained in the appendix, it is not probable that the complete saving due to cross filling can be realized, since this would require that at each lockage one-half of the upper lock of the flight is to be spilled into its twin. This will practically always be possible at the end of every uplockage, since the locks in the downbound flight are left empty after use, while those in the upbound flight are left full. Practically every time, therefore, that an upbound vessel leaves the upper lock, one-half of the prism can be transferred to the twin in the downbound flight. The upbound flight would then be

operated at the reduced level, while the downbound flight would be operated at normal levels. It is this maneuver that results in the saving at Gatun of 8 per cent, and the actual saving will probably be between this value and the maximum of 24 per cent.

Let us now examine what the expenditures would be at Gatun were the intermediate gates to be omitted from the two lower locks. It would then still be possible to utilize the upper 550-foot lock, as its prism of lift, even if spilled into the entire middle lock, would still be sufficient to give draft over the lower sill of the upper lock adequate for most vessels not more than 550 feet long. Nevertheless, inasmuch as the area of the 550-foot upper lock is only 82,500 square feet, while the area of the middle lock into which it would spill would be 120,000 square feet, it follows that equalization would take place at a level considerably lower than when the upper 550-foot lock is spilled into an intermediate 550-foot lock of approximately its own area. The difference between these two levels of equalization represents the altitude of a prism saved when the intermediate gates are used in the middle lock, and lost when they are omitted. As shown in the appendix, if the intermediate gates in the two lower locks should be omitted, the lift from the upper 550-foot lock to the middle lock under normal conditions would be 35.80 feet, the normal prism of lift would be 2,953,000 cubic feet and the draft over the lower sill of the upper lock would be 34.20 feet. With the lake at +82 and sea at −1, this latter draft would be reduced to 32.04 feet. As the prism of lift of the 550-foot lock when lower gates are introduced in the lower locks is 2,300,000 cubic feet at normal levels, it follows that the omission of these gates would cause a loss at Gatun of 652,000 cubic feet for each 550-foot lockage, or about 28½ per cent of the normal expenditure in such lockage. Further, if under similar conditions the 550-foot lock should be cross filled with its neighbor in order to save water, the smaller prism then thrown down into the large intermediate lock would cause a still greater diminution of depth over the sill, and at normal conditions this would be reduced to 19.4 feet, and, at stages of +82 and −1, to 17.8 feet. These depths would be insufficient for many vessels which could use the 550-foot lock. It follows, therefore, that the omission of the intermediate gates in the middle and lower locks at Gatun would result, first, in the direct loss of 28½ per cent of the lockage water at each 550-foot lockage, and, second, in the practical nullification of the opportunity of saving water by cross filling in the 550-foot locks. The omission of the intermediate gates in the lowest lock of the Gatun flight, while retaining them in the middle and upper locks, would result in a normal lockage prism being drawn from the upper pool of 31.34 feet in altitude, with a critical depth of 35.12 feet at each 550-foot lockage, and a loss of water of 12 per cent of the present expenditure in 550-foot lockages. The cross-filled depth with this arrangement would reduce to about 22 feet, with the lake at +82 and the sea at −1.

The omission of the intermediate gates in both middle and lower locks would reduce the normal depth and increase the expenditure in the 350-foot lock very greatly. Assuming that 50 per cent of the lockages at Gatun will be in the 550-foot lock, and 30 per cent in the 350-foot lock, the total expenditure of water at the flight would be increased over that, due to the use of intermediate gates, by about 26 per cent if the intermediate gates should be omitted from both the

middle and lower locks and by about 10 per cent if the gates should be omitted from the lower lock only, retaining them in the middle lock.

While the saving in money due to the omission of the intermediate gates in both the middle and lower locks at Gatun would amount to about $900,000, it has seemed to me that the extra expenditure of water is worth more than this saving in first cost, and the gates have been included in the adopted design.

LOCK FLIGHT AT MIRAFLORES.

The analysis of the levels and lifts in the Miraflores locks is seriously complicated by the tidal variation. This has been known to reach 23 feet when extreme stages in the rivers have coincided with extreme tides. Taking into consideration, however, the clearing of the channels and the additional reservoir capacity afforded by Miraflores Lake, both of which will work to decrease the effect of the rivers at the lock site, it does not seem necessary to provide for so great a variation, and in the design high tide has been assumed at +10 and low tide at −10.

It is manifest that if the coping of the lower lock be placed at such a level as to contain exactly the prism of lift from the upper lock at low or at mean tide it will be flooded at high tide unless the excess of water be wasted. As will be seen in the appendix, the coping would have to be placed at reference +37.75 in order to contain the prism of lift at high tide, without waste, and with an adequate freeboard. The level which has been chosen for the coping in the lower lock, viz, +32, results in gates 82 feet high, the highest in the canal. A further raising of the coping level would have meant a corresponding increase in the height of the gates and increase in cost for the masonry. It is estimated that to build the wall to the reference 37.75 would add about $500,000 to the cost of the lock. This item, although important, does not necessarily control. The marked increase in height of the gate, however, is a very serious matter. Even with the coping of the wall placed as now proposed, the gates will be 3 feet higher than the next largest ones on the canal. Their height is already extreme, and, while a further increase of 5.75 to 87.75 feet may be possible, I feel that in going to 82 feet we have taken as long a step as is proper; and I should have recommended placing the coping at even a lower reference were it not for the manifest advantage of using the 550-foot-lock prism at all stages of the tide without wasting water. I know of no examples of gates which approach in height those which we shall now have to build, and am convinced that it is better to sacrifice some water at high stages at Miraflores rather than to make a considerable increase in this already unprecedented dimension. The coping level selected is such that the lower lock, having no intermediate gates, will receive the prism of lift of the 550-foot upper lock at all stages of tide without flooding its walls or machinery pits. It will similarly receive the cross-filled prism from the 1,000 or 900-foot upper lock at all stages. It will receive the full prism of these larger locks to a stage of 2.15 feet below mean tide for the 1,000-foot, and to practically mean tide for the 900-foot lock, without waste. At higher stages waste of water ensues when the largest locks are used. The 550-foot lock, which will be the one most used, can there-

fore be used at all stages in the ordinary manner. The other locks can be used with full prism at low stages of the tide in the ordinary manner. They can be used, if cross emptied, at all stages of the tide without waste of water, and they can be used at all stages by allowing the excess of water to escape to the sea level through the culverts of the lower lock before the walls or pits are flooded.

Considering, first, the 1,000-foot lock, it will be found, as shown in the appendix, that with the lake at +55 and the sea at −10 the prism of lift is 30.71 feet in altitude and contains 4,115,000 cubic feet, the minimum depth being that over the lower sill, namely, 40 feet. At high tide the prism of lift is 27 feet in altitude and contains 3,618,000 cubic feet. Of this last amount only 2,160,000 cubic feet can be passed into the lower lock, and the difference, namely, 1,450,000 cubic feet, must be wasted through the culverts. The average prism of lift for all stages is 3,716,000 cubic feet.

For the 1,000-foot lock wasting begins at stage of −2.15, or a little over 2 feet below mean tide. As explained in the appendix, to avoid wasting the walls of the lock would have to be carried to +37.75, in which case the average prism of lift would be 3,482,000 cubic feet. This increase in height of the walls with its attendant increase in height of gates and great expense in masonry would result in saving about 6.4 per cent of the water which will now be used in the 1,000-foot lockages.

It will be remembered that the 1,000-foot lock need be used only for vessels of extreme size in case of the down lockage, and that for the up lockage the 900-foot lock is sufficient even for these vessels.

For the 900-foot lock at Miraflores wasting must begin at 0.32 foot above mean tide. The average prism of lift contains 3,484,000 cubic feet. Were the walls raised sufficiently to contain the prism without overflowing at high tide, the average prism of lift would be 3,302,000 cubic feet. Hence the average loss due to leaving the coping low is about 5 per cent of the present expenditure for the 900-foot lock.

Instead of wasting a portion of the prism of the 1,000 and 900-foot lockages at Miraflores, it will in many cases be possible to pass a part, up to one-half the prism of the upper lock, into its twin, thereby saving it to the upper level. As in the case of the Gatun flight, this is possible practically always when the upper lock has just passed a vessel going upward. It may then be robbed of one-half its prism by passing it over into its twin lock, which is habitually at the low level. The possibility, however, will not always exist in the case of the reverse operation.

As shown in the appendix, the theoretical saving at Miraflores, due to cross filling—i. e., the saving when this method can be resorted to at all down lockages as well as up lockages—would reach 36 per cent of the prism used at the average lockage in case of both the 900 and 1,000-foot locks.

If it be assumed that cross filling takes place only in one flight, leaving the other flight to be worked with full prism, a maneuver which, as previously stated, is practically always possible, the saving due to cross filling at Miraflores is 15 per cent of the present expenditure in case of the 1,000 and 900-foot locks.

The minimum depth at high tide in the 1,000-foot cross-filled lock is 44.45 feet, and at low tide is 31.61 feet. In the 900-foot lock cross filled the corresponding minimum depths are 43.57 and 30.33 feet.

In case of the 550-foot lock at Miraflores the average prism of lift is 2,690,000 cubic feet, or 74 per cent of the 1,000-foot prism, and the minimum depth—i. e., the depth at low tide—is 34.81 feet. No wasting of water through the culverts is necessary. The coping of the lower wall, as designed, is at such a reference that the lower chamber, without intermediate gates, will contain the entire prism of lift of the 550-foot upper chamber, even at high tide, with an adequate freeboard. Nevertheless, due to the larger area of the lower chamber, equalization takes place at a lower level than it would were the lower lock provided with intermediate gates and the coping raised sufficiently to let the 550-foot lower chamber contain the entire prism of lift from the corresponding upper chamber. This would require raising the coping to approximately the same reference as in the case of the 1,000-foot lockage, viz, 37.75, and, as previously stated, such a design has been considered impracticable. Nevertheless, even with the coping left at its present reference, a certain saving of water could still be effected by introducing intermediate gates in the lower locks. Were these introduced they could be used from low tide up to approximately mean stage, during which time the entire 550-foot upper prism could be contained in the 550-foot lower chamber. For this range of tide, therefore, equalization between these two prisms would take place at a higher reference than will be the case when the upper 550-foot lock is emptied into the lower 1,000-foot lock. Above mean tide, however, the lower 550-foot chamber would not contain the upper 550-foot prism. The main saving, therefore, could only take place between low tide and the stage at which the 550-foot locks could be equalized into each other without raising the level in the lower of the two to a dangerous height. It appears from examination (see appendix, p. 108) that the presence of lower gates at Miraflores would save about 10 per cent of the expenditure of water at that flight as now designed.

The water supply available for the canal appears ample to permit the passage of as many vessels as can use the locks in the twenty-four hours, even if the intermediate gates be omitted in the lower lock on one side or the other. To omit them in the lower lock at Gatun causes practically the same loss as to omit them at Miraflores and is less advantageous in other ways. The actual monetary saving at Miraflores is greater than it would be at Gatun, since the gates and walls are higher. Furthermore, due to the tidal effect at Miraflores, which is not injurious at Gatun, the introduction of intermediate gates in the lower lock would make it necessary to waste water in the 550-foot lockages, and to use care to avoid flooding the walls, just as must be done in the adopted design in case of the 900 and 1,000-foot lockages. In the latter two lockages this disadvantage must be accepted as unavoidable. It may, however, be avoided in the 550-foot lockages, which will probably be by far the most frequent, by omitting the intermediate gates in the lower lock. For these reasons, therefore, I have thought it best to accept the additional expenditure of water and to design the lower chamber without intermediate gates. The saving in cost by omitting these gates is about $512,000.

The average theoretical prism of lift for the 550-foot lock, cross filled, is 1,690,000 cubic feet, and the critical depth is 39.83 feet, at high tide and 24.93 feet at low tide. The saving in this case, as in the case of the larger locks when both flights are assumed to be cross filled at

every lockage, is about 36 per cent of the uncross-filled expenditure. When but one of the flights is so worked the saving is, as before, about 15 per cent, but the minimum depth is materially increased.

In the 350-foot lock at Miraflores, the theoretical prism of lift for the lockage in the 51,500-foot lock is 1,378,000 cubic feet. The average expenditure, however, calculated as in the case of the Gatun flight, for a series of three 350-foot lockages, followed by a 550-foot lockage, is 1,593,000 cubic feet.

In the foregoing discussion of the Miraflores lock flight, the level of the lake has been assumed at +55. In reality the theoretical level is $+54\frac{2}{3}$. Taking the higher reference, however, has served to increase the apparent lockage expenditure somewhat, and in so doing has erred on the safe side.

SINGLE-LIFT LOCK AT PEDRO MIGUEL.

The normal lift at Pedro Miguel is from reference +85 to reference $+54\frac{2}{3}$, or $30\frac{1}{3}$ feet. The lockage prisms, therefore, are as follows:

	Cubic feet.
For the 1,000-foot lock	4,065,000
For the 900-foot lock	3,731,000
For the 550-foot lock	2,500,000
For the 350-foot lock (larger)	962,000
For the 350-foot lock (smaller)	824,000

In a single-lift lock like the one at Pedro Miguel, where the area in the stretches of the canal above and below is so large that the levels of these stretches are practically unaffected by drawing off or adding a lockage prism, it is evident that the necessity does not exist, as it does in the case of a flight of locks, of taking down into the lock below a stated amount of water in order to raise the water level in the lower lock to meet the descending level in the upper lock at the proper reference. It follows, therefore, that complete saving can be made of the water which can be drawn from one lock to its twin through the middle wall, and that increased advantage can be obtained by using the 350-foot lock chamber for small vessels. Also, that no diminution of the saving thus made will be caused by an interruption of the series of small lockages by larger vessels requiring the large locks.

It has been shown that, in the case of the Gatun locks, it is only in the 550-foot downbound flight that an interruption of the series of small lockages by a larger lockage will not nullify part of the saving due to using the shorter lock, while at Pedro Miguel there is no such nullification except in the 350-foot up-lockage. It has also been shown that the saving due to the cross filling at Gatun is much lessened because of the influence which taking down the smaller prism of water has in lowering the levels of equalization in the locks below, thereby not only diminishing the draft over the sills, but also increasing the height of the prism taken down and at the same time requiring greater draft upon the upper pool to restore levels needed for large vessels upon interruption of the series. Similar inconvenience is felt at Miraflores, but at the single-lift lock, as will be seen in the appendix, page 109, increased saving due to using the shorter prism can be made, a 50 per cent saving due to cross filling can also be made in theory, and a 25 per cent saving by cross filling

can be counted upon. The corresponding theoretical and certain savings are, at Gatun, 24 and 8 per cent, and at Miraflores, 36 and 15 per cent. Furthermore, it would be more practicable to alternate vessels passing up and down in single-lift locks than in a flight of locks, since such action would not cause so long a delay. By this maneuver 50 per cent of the lockage water can always be saved. It is hardly probable, however, that the locks would be so used on the Panama Canal, except in case of emergency, since regularity of passage dictates reserving each flight for vessels passing in one direction only. It follows that economy in water can be effected in twin locks similar to those used on the Isthmian Canal, if such locks can be separated into single lifts rather than consolidated into flights of two or more lifts.

It may also be stated that such a disposition of locks—i. e., an arrangement of single lifts separated by levels—would have reduced the working pressures and thereby simplified the design of the details greatly, and would have avoided the waste of water now necessary in the large locks at Miraflores at high stages of the tide. While it is recognized, therefore, that the combination of the locks, as planned, in flights, results in economy of money, conditions of foundation and location being equal, it nevertheless carries with it the disadvantage of increasing the expenditure of water both by reducing the possibility of saving presented by the adopted design of the locks and by causing waste at high stages of tide. The reduction in possible saving is greater in the case of a three-lock flight than in case of a two-lock flight, and for this reason it appears that economy in water has resulted from preserving the separation of the Miraflores and Pedro Miguel locks instead of uniting the three in one flight. The actual expenditure at Miraflores is greater than at Gatun, but this fact results from the necessary wastage at low tide, and from the omission of the intermediate gates in the lower lock. A three-lock flight similarly designed and placed would use still more water.

During the dry season, at which time alone economy in the use of water is of any importance, the main supply of the Miraflores lock flight must come through Pedro Miguel, since the direct flow of the tributaries of Miraflores Lake is very small at that time. For this reason full use can not be made of a possibility of saving which the single lift at Pedro Miguel offers. The expenditure in lockages must therefore be determined by the lock flights at Miraflores and Gatun, rather than by Gatun and Pedro Miguel, and through the last an amount of water must be passed down sufficient, when combined with the natural supply, to keep the level of Miraflores Lake sensibly constant at $54\frac{2}{3}$ feet. Any excess of water will escape over the spillway at Miraflores.

Assuming that 30 per cent of the vessels passing the canal will use the 350-foot lock, that one-half of them will use the 550-foot lock, that 15 per cent of them will require the 900-foot lock, and that 5 per cent of them will require a chamber 1,000 feet long, and remembering that the last-named class of vessels, which, when going down, require the 1,000-foot lock, can, on going up, use the 900-foot lock, we shall find that in passing 100 single vessels the 1,000-foot lock will be used two and one-half times, the 900-foot lock seventeen and one-half times, the 550-foot lock fifty times, and the 350-foot lock thirty times. For one complete passage of the canal each day the expendi-

ture will correspond under these assumptions to a continuous flow of 54.6 feet per second, as shown in the following table, without reckoning the saving possible by cross filling.

1	2	3	4	5	6	7	8
Lock.	Prism of lift in 1,000 cubic feet.			Sum of 2 and 4.	Column 5 in second feet.	Weight.	Column 5 weighted.
	Gatun.	Pedro Miguel.	Miraflores.				
						Per cent.	
1,000-foot	3,545	4,065	3,716	7,259	84.0	2.5	2.1
900-foot	3,446	3,730	3,484	6,930	80.2	17.5	14.0
550-foot	2,300	2,500	2,690	4,990	57.8	50.0	28.9
350-foot	1,181	928	1,593	2,774	32.1	30.0	9.6
Total							54.6

This expenditure may fairly be assumed to be reduced 15 per cent by cross filling, making the average expenditure of a complete passage of the canal 46.4 per second.

During the last nineteen years the lowest discharge which has been known at Gatun was in the season of 1908, being 930 feet per second during the three driest months and 1,190 feet per second during the four driest months. The area of the lake at different stages is as follows:

	Square miles.
At +80	153.32
At +85	163.38
At +90	173.44

If we assume that the canal may be considered as navigable even for large vessels until the lake reaches the level of +80, there will be 7 feet of storage available, which, allowing the lake between these stages to have an area of 159 square miles, is equivalent to a flow of 2,993 feet per second for one hundred and twenty days. This added to the minimum four months' discharge assures a supply of 4,183 feet per second. Making the assumptions usual in previous discussions of the water supply here as follows:

	Feet per second.
Evaporation	930
Seepage	85
Leakage	275
Light, power, etc	275

we have a total expenditure from these causes of 1,565 feet per second, leaving available for lockages 2,618 feet per second. This at the cross-filled value would allow 48 complete passages of the Isthmus per day with a surplus of about 400 feet per second. Considering only the storage available above reference +82—i. e., a depth of storage of only 5 feet, with average lake area of 162 square miles—it will be found that an average number of 38.8 complete passages per day of the canal can be made during the dry period of four months.

In the year 1909 the business of the canal on the American side at Sault Ste. Marie, amounting to, say, 30,000,000 tons, was carried on an average of 57 passages per diem for eight months of the year, or an

average for the whole year of about 38 passages, while the business of Suez Canal during the same year, when it reached the largest total since the canal was built and amounted to about 15,500,000 net tons, was carried on an average of about 12 passages per diem.

The foregoing discussion relates to the worst known dry season in nineteen years. In the average dry season the flow tributary to the lake is approximately 3,000 feet per second, which quantity when assisted by the stored water is evidently much more than would be needed to carry any navigation which time would permit to pass the locks.

In the foregoing calculations the observed evaporation on the Isthmus of 6.34 inches per month during the dry season has been allowed for. No credit, however, has been taken for the fact that when this evaporation begins—i. e., when the lake area is flooded—the loss of the water now given off by the vegetation in that area will cease. This loss now reduces the apparently available water supply, which is estimated from the measured discharge of the rivers and not from the rainfall and catchment area. The amount of water given off by growing vegetation may be large and in the case of certain plants has been known to reach values exceeding that assumed for the evaporation.

Respectfully submitted.

H. F. Hodges,
Assistant Chief Engineer.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.

APPENDIX TO APPENDIX "B."

GENERAL FORMULA FOR LIFTS OF FLIGHT OF THREE LOCKS OF DIFFERENT AREAS.

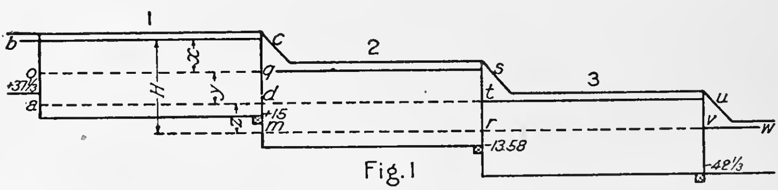


Fig. 1

In the figure above, let $b\ c$ represent the lake level, $w\ v$ the sea level below, and $u\ t$ the upper level in the lowest lock, which is prolonged to d and a. Represent the total vertical lift between the lake level and the sea level by H, and the lift $c\ q$ of the first lock, measured from its high level to the high level of the middle lock, by x; the lift $s\ t$ of the middle lock by y; and the lift $u\ v$ of the lowest lock by z. Assume that a vessel has just passed down the flight of locks, such operation necessarily leaving all the locks at their low levels, and assume that the upper lock has just been filled to the level $b\ c$ to admit a second vessel going down, we have then the water in the middle lock at its low level $d\ t$ and the water in the lowest lock at sea level $v\ w$. In the upper and middle lock the total quantity

of water now lying above the low level $t\,d$ of the middle lock is the prism $a\,b\,c\,d$. If, now, the valves in the barrier $a\,b$ be closed and those in the barrier $c\,d$ be opened, and the water in the upper lock be allowed to flow into the middle lock until the levels are equalized, no water can have escaped from the system comprising the two locks, and after this operation the total amount of water in the system lying above the datum level $t\,d$ must be the same as it was before; but, after equalization, this total amount of water is the prism $a\,t\,s\,o$. It follows, therefore, that prism $a\,t\,s\,o$ is equal in volume to the prism $a\,b\,c\,d$. Representing the area of the upper, middle, and lower locks by A, A_1, and A_2, respectively, we have, from the stated equality of prisms, $A\,(x+y) = (A + A_1)\,y$, or, reducing, $A\,x = A_1\,y$. (1).

The level in the middle lock is now at $q\,s$, and the valves in the barrier $c\,d$ may be closed, cutting off the upper lock. In the middle and lower locks the total amount of water now lying above the level $w\,v\,m$ is the prism $m\,q\,s\,r$. Opening the valves in the barrier $s\,r$, the pools in the middle and lower locks will equalize at some level $u\,t$, intermediate between $v\,r$ and $s\,q$; but, since the system comprising these two locks is isolated by the barriers $c\,d$ and $u\,v$ from outside communication, it follows that the total amount of water remaining above the datum plane $v\,r$ must be the same as it was before, and we have, therefore, the prism $m\,q\,s\,r$ equal to the prism $m\,d\,u\,v$, or,

$$A_1\,(y+z) = (A_1 + A_2)\,z, \therefore A_1\,y = A_2\,z. \quad (2).$$

By hypothesis, $x+y+z=H$. (3).

Substituting, in equation (3), the values of y and z in terms of x derived from (1) and (2), we have—

$$x\left(1+\frac{A}{A_1}+\frac{A}{A_2}\right)=H \qquad x=\frac{A_1A_2H}{AA_1+AA_2+A_1A_2}$$

$$y=\frac{A\,A_2H}{A\,A_1+A\,A_2+A_1A_2}$$

and

$$z=\frac{A\,A_1H}{A\,A_1+A_1A_2+A\,A_2}$$

Application to Gatun flight, 1,000-foot lock.—At Gatun the areas of the locks are: $A = 134{,}000$ square feet, $A_1 = 121{,}000$ square feet, $A_2 =$ 121,000 square feet. H, at mean tide and normal lake level, is 85 feet.

Making proper substitutions, we have, therefore,

$$x=\frac{H}{1+\frac{2A}{A_1}}=26.44 \text{ feet.}$$

$$y=z=29.28 \text{ feet.}$$

The prism of lift—i. e., the water which passes through the lower gate of the upper lock in making the lockage is $121{,}000 \times 29.28$, or, say, 3,543,000 cubic feet. Under other conditions of lake and sea level, which vary the value of H, the lifts may be similarly determined. The typical cases are tabulated as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +85, sea at 0:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+85.00	26.44	43.56
Middle lock	+58.56	29.28	42.86
Lower lock	+29.28	29.28	42.33
Sea	0.00	....	....
Lake at +87, sea at +1:			
Upper lock	+87.00	26.76	45.24
Middle lock	+60.24	29.62	44.20
Lower lock	+30.62	29.62	43.33
Sea	+ 1.00	....	....
Lake at +87, sea at −1:			
Upper lock	+87.00	27.38	44.62
Middle lock	+59.62	30.31	42.89
Lower lock	+29.31	30.31	41.33
Sea	− 1.00	....	....
Lake at +82, sea at +1:			
Upper lock	+82.00	25.20	41.80
Middle lock	+56.80	27.90	42.48
Lower lock	+28.90	27.90	43.33
Sea	+ 1.00	....	....
Lake at +82, sea at −1:			
Upper lock	+82.00	25.82	41.18
Middle lock	+56.18	28.59	41.17
Lower lock	+27.59	28.59	41.33
Sea	− 1.00	....	....

With the lake level at +80 and the sea at −1, the least depth is 39.80 feet.

The above values apply to the full 1,000-foot upper lock, which utilizes, as part of its chamber, the space between the two upper pairs of gates.

The 900-foot lock may be taken as a particular case of the 1,000-foot lock, and will be used in connection with the 1,000-foot middle and lower locks for all vessels too large for the 550-foot lock, except those of extreme size. For this lock the value of A is 123,000 square feet, and of A_1, as before, 121,000 square feet. For the normal conditions of the lake at +85 and the sea at 0, x becomes 28.02 feet, and $y=z$, 28.49 feet. The lockage prism under these conditions is 3,446,000 cubic feet. The typical cases are tabulated below.

	High level.	Lift.	Depth over lower sill.
Lake at +85, sea at 0:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+85.00	28.02	41.98
Middle lock	+56.98	28.49	42.07
Lower lock	+28.49	28.49	42.33
Sea	0.00	....	....
Lake at +87, sea at +1:			
Upper lock	+87.00	28.36	43.64
Middle lock	+58.64	28.82	43.40
Lower lock	+29.82	28.82	43.33
Sea	+ 1.00	....	....
Lake at +87, sea at −1:			
Upper lock	+87.00	29.02	42.98
Middle lock	+57.98	29.49	42.07
Lower lock	+28.49	29.49	41.33
Sea	− 1.00	....	....
Lake at +82, sea at +1:			
Upper lock	+82.00	26.70	40.30
Middle lock	+55.30	27.15	41.73
Lower lock	+28.15	27.15	43.33
Sea	+ 1.00	....	....
Lake at +82, sea at −1:			
Upper lock	+82.00	27.36	39.64
Middle lock	+54.64	27.82	40.40
Lower lock	+26.82	27.82	41.33
Sea	− 1.00	....	....

With lake at +80 and sea at −1, the least depth is 38.30 feet.

SAVING DUE TO INTERMEDIATE GATES.

In the report of the board of consulting engineers of 1905, page 75, it is stated that intermediate gates in a three-lock flight would not furnish the same advantage of saving water as in single lift or double lift flights and that therefore they would be omitted in the flight at Gatun. After the report of the board was rendered, General Abbot, in talking the matter over once with the writer, stated that a saving could still be made in a three-lift flight by the use of intermediate gates, and he was quite correct in his statement.

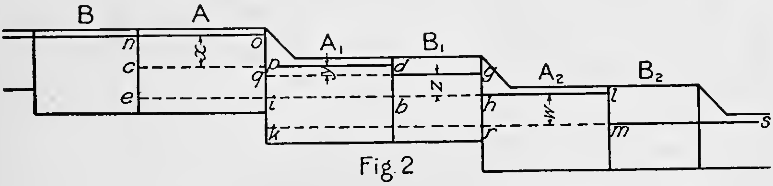


Fig. 2

Let the above figure represent a three-lift flight in which each lock is divided into the large chambers A, A_1, and A_2, equal in area, which we will call A, and small chambers B, B_1, and B_2, in which B is larger than the others, and B_1 and B_2 are equal in area, which we will call B_1. Suppose a vessel to have passed down using chambers A; then, since it must pass from lock A_1 to A_2, through B_1, and the gate $g\ r$ must then be shut to lower the boat to sea level, it follows that the level in B_1, as well as in A_1, after the downward passage of the vessel, will be the high level of the lock A_2. Represent the lifts between the high levels of successive subdivisions as follows: B to A, o; A to A_1, x; A_1 to B_1, y; B_1 to A_2, z; A_2 to sea, w. Fill A to lake level $n\ o$ and admit vessel. Close barrier $n\ e$. Then, since the level in A_1 and B_1 is the high level of A_2, represented by the line $e\ l$, the total amount of water above that level $e\ l$ in the two locks A and A_1 before equalizing is represented by the prism $n\ e\ i\ o$. If, now, keeping the gates and valves in the barriers $n\ e$ and $d\ b$ closed, the valves in the barrier $o\ i$ be opened, the water level $n\ o$ in A, and $i\ b$ in A_1 will equalize at some level $p\ d$. The prism $c\ e\ b\ d$, which is now above $e\ l$, must be equal to the prism $n\ e\ i\ o$, which was above that level before equalizing. From this we have, since $o\ p$ is equal to x, $p\ q$ to y and $q\ i$ to z,

$$(1) \quad A(x+y+z)=2A(y+z);\ \text{hence},\ x=y+z.$$

Since the barrier at $d\ b$ was kept closed, the level in B_1 during this operation has remained at $b\ h$. Let the vessel now be passed into the lock A_1 and the gate and valves in $o\ k$ be closed. In A_1 and B_1 the total prism above $b\ h$ is $p\ i\ b\ d$ equal to $A\ (z+y)$. Open the valves in $d\ b$ and the water levels in A_1 and B_1 will equalize at some level $q\ g$, the total prism above $b\ h$ now being $q\ i\ h\ g$ equal to $(A+B_1)z$. Equating these two prisms we have—

$$(2) \quad A(y+z)=(A+B_1)z;\ \text{hence}\ z=\frac{Ay}{B_1}.$$

Now open gate $d\ b$, making one chamber of A_1 and B_1, and open valves in $g\ r$, equalizing levels between chamber A_1–B_1, and the chamber A_2, in which the water level now is at the line $r\ m$. Equal-

ization will take place at some level $h\ l$, at a distance w above the sea level, and by the reasoning already followed we have the prism $q\ k\ r\ g$ equal to the prism $i\ k\ m\ l$, or,

$$(3)\quad (A+B_1)\ (z+w)=(2A+B_1)w;\ \text{hence}\ Aw=z(A+B_1).$$

Combining (2) and (3), we have—

$$w=\frac{y}{B_1}(A+B_1)=\frac{Ay}{B_1}+y.$$

Combining (1) and (2), we have—

$$x=\frac{Ay}{B_1}+y;\ \text{hence}\ x=w.$$

We find, therefore, that x, which we know to be equal to $y+z$, is also equal to w, and that the lifts of all the chambers A are consequently the same.

Admitting, now, the vessel to the chamber A_2 and closing barrier $g\ r$, the water in A_2 can be lowered to sea level through the valves in $l\ m$, and the vessel passed out through B_2 with the total loss of the prism $h\ r\ m\ l$, which is $A\ w$ and equal to the prism $A\ x$, originally taken from the upper level. The levels in the flight will be left as found.

In order to accomplish the result it is necessary only that after the vessel has been admitted from the combined lock chamber A_1+B_1, to the chamber A_2, closed below by the barrier $l\ m$, the barrier $q\ r$ should be closed behind it before it is lowered from the level $h\ l$ to sea level. In this way the vessel drawing full draft has been passed through the flight with only the expenditure of water due to the prism of area A, and the height x, or, $y+z$, or w, equal to one-third of H. The prism B_1 becomes practically a portion of an intermediate canal, the water level never going below the normal high level $h\ l$ in A_2.

There is no necessity for making two operations as indicated above of lowering the vessel from $p\ d$ to $h\ l$. The valves in $d\ b$ and $g\ r$ may be opened at the same time, allowing the prisms in A_1 and B_1 to flow simultaneously into A_2, thus avoiding a slight loss of time.

550-FOOT LOCKS AT GATUN.

In the foregoing discussion absolute equality between the areas of the large chambers has been assumed for the sake of simplicity. In point of fact, at Gatun the upper 550-foot lock has a greater area than the two lower ones. This difference in area is sufficient to be taken into consideration in determining the conditions of water levels and lifts for different stages of lake and sea. The equations to determine the values of the lifts between the upper, middle, and lower 550-foot locks are as in the case of the 1,000-foot lock:

$$(1)\quad x=\frac{A_1}{A}\ (y+z)=\frac{(A_1+B_1)}{A}\ z=\frac{A_1\ H}{2A+A_1}$$

$$(2)\quad y+z=w=\frac{AH}{2A+A_1}$$

$$(3)\quad x+y+z+w=H.$$

At Gatun the area of the upper 550-foot lock is 82,500 square feet, and the areas of the two lower 550-foot locks A_1 and A_2 are the same, viz, 80,500 square feet. For the normal conditions of lake level +85 and sea level 0, we have therefore the lift of the upper lock 27.88 feet, and of the two lower locks 28.56 feet. The prism of lift under these conditions is 2,300,000 cubic feet, and the saving over the 1,000-foot lock prism is 3,543,000 − 2,300,000 = 1,243,000, or about one-third of the 1,000-foot prism.

The typical conditions of water levels and lifts are tabulated below:

550-foot lock.

	High level.	Lift.	Depth over lower sill.
Lake at +85, sea at 0:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+85.00	27.88	42.12
Middle lock	+57.12	28.56	42.13
Lower lock	+28.56	28.56	42.33
Sea	0.00		
Lake at +87, sea at −1:			
Upper lock	+87.00	28.88	43.12
Middle lock	+58.12	29.56	42.14
Lower lock	+28.56	29.56	41.33
Sea	− 1.00		
Lake at +87, sea at +1:			
Upper lock	+87.00	28.22	43.78
Middle lock	+58.78	28.89	43.47
Lower lock	+29.89	28.89	43.33
Sea	+ 1.00		
Lake at +82, sea at −1:			
Upper lock	+82.00	27.24	39.76
Middle lock	+54.76	27.88	40.46
Lower lock	+26.88	27.88	41.33
Sea	− 1.00		
Lake at +82, sea at +1:			
Upper lock	+82.00	26.58	40.42
Middle lock	+55.42	27.21	41.79
Lower lock	+28.21	27.21	43.33
Sea	+ 1.00		

With lake at +80 and sea at −1, the least depth is 38.42 feet.

It has been stated in discussing the downbound lockages in the 550-foot lock that the 350-foot middle lock becomes simply a short stretch of intermediate canal, the water always remaining at the high level of the lower lock, which is the level at which it is found. In the upbound flight, however, in which, after passage of the vessel, all the locks are left full, the level of the water in this short stretch of canal is found at high level of the middle lock at the beginning of the 550-foot lockages, and will be left at the high level of the lowest lock at the end of the series. If the series of 550-foot vessels be followed by a large vessel requiring one of the larger locks, it may be necessary to restore to the system the amount of water required to raise this middle 350-foot lock from the high level of the lower lock to the high level of the middle lock in order to provide sufficient draft for the large vessel needing the large lock. To do this would nullify the saving due to one of the previous 550-foot lockages. Without doing so, however, a vessel of considerable draft can be passed up. The prism to be sent down from the middle lock to the lower lock is composed of two parts, the 550-foot middle lock with upper surface at reference 57.10 and the 350-foot middle lock with upper surface at

reference 28.55. When both these prisms are passed down into the lowest lock at level 0, the resulting plane of equalization will be found at $80{,}500 \times \frac{57.12 + 40{,}500 \times 28.56}{2 \times 121{,}000} = 23.77$, giving a draft of 37.35 over the lower sill of the middle lock, which is the critical point. Equalizing, now, the upper 1,000-foot lock into the middle lock at 23.77, it is found that equalization will take place at reference 55.95. Normally, in 1,000-foot lockages, the upper and middle locks equalize at reference 58.56. It is seen, therefore, that when the large vessel is passed up without refilling the 350-foot middle lock, a prism 2.61 feet in height in excess of the normal expenditure will be drawn from the upper level. This amounts to a volume of 350,000 cubic feet, and it follows that the interruption of the series of the 550-foot up-lockages by a large vessel of not more than 37.35 feet draft will nullify only this amount of the previous saving, or about 30 per cent of the saving due to each 550-foot lockage.

350-FOOT LOCK AT GATUN.

The general equations for determining the conditions of lift and level in the 350-foot lock are as follows:

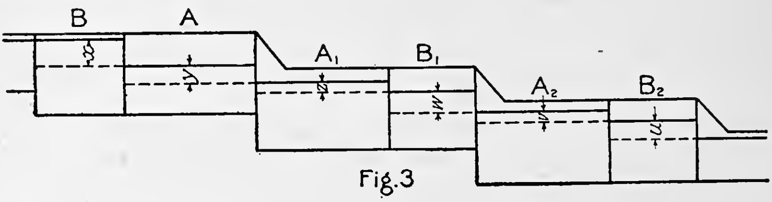


Fig. 3

$$(1)\quad B\,(x+y) = (A+B)\,y \qquad (2)\quad A\,(y+z) = (A+A_1)\,z$$
$$(3)\quad A_1\,(z+w) = (A_1+B_1)\,w \qquad (4)\quad B_1\,(w+v) = (B_1+A_2)\,v$$
$$(5)\quad A_2\,(v+u) = (A_2+B_2)\,u \qquad (6)\quad x+y+z+w+v+u = H.$$

Six equations containing six unknowns.

From (1) we have (7), $x = \frac{Ay}{B}$

From (2) we have (8), $z = \frac{Ay}{A_1}$

From (3) and (8) we have (9), $w = \frac{Ay}{B_1}$

From (4), since $A_1 = A_2$, we have $w = \frac{A_1 v}{B_1} = \frac{Ay}{B_1} \therefore$ (10) $v = \frac{Ay}{A_1} = z$

From (5), since $B_2 = B_1$, and $A_2 = A_1$, we have $v = \frac{B_1 u}{A_1} = \frac{Ay}{A_1}$,

$$\therefore (11)\ u = \frac{Ay}{B_1} = w.$$

From above, substituting in (6)

$$y\left(\frac{A}{B} + \frac{A}{A_1} + \frac{A}{B_1} + \frac{A}{A_1} + \frac{A}{B_1} + 1\right) = H.$$

For the normal case in the above equation, $A=82{,}500$ square feet, $A_1=A_2=80{,}500$ square feet; B, including the space between the two pairs of upper gates, $=51{,}500$, and $B_1=B_2=40{,}500$ square feet, and $H=85$. We have, therefore, conditions of lifts and levels as follows:

	High level.	Low level.	Lift.
	Feet.	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	69.39	15.61
Upper 550-foot lock	69.39	59.65	9.74
Middle 550-foot lock	59.65	49.66	9.99
Middle 350-foot lock	49.66	29.82	19.84
Lower 550-foot lock	29.82	19.84	9.99
Lower 350-foot lock	19.84	0.00	19.84

Prism of lift, say, 804,000 cubic feet.

The foregoing results imply that there has been a series of 350-foot lockages until the theoretical conditions of level have been established. The most common lockage, however, will undoubtedly be the 550-foot lockage, and usually, when a small vessel comes along, the locks will not be found precisely right for the 350-foot lockage, but will be set for the 550-foot lockage. If we assume that a succession of 350-foot vessels follows a 550-foot vessel, the conditions will approach the theoretical conditions very gradually, as is seen in the following table (p. 84), which gives the conditions of lift and level after each successive 350-foot lockage up to three, as compared with the theoretical conditions.

In computing the prisms of lift for the 350-foot locks, that water is counted as lost to the upper level which is passed down through the lower valves of the 1,000-foot upper locks. For all locks except the 350-foot lock it is immaterial whether the count is made at the upper or lower gates, or even at the upper or lower end of the flight; and for the 350-foot lock, also, it makes no difference where the count is taken in a continuous series of lockages. If, however, only a small number of 350-foot lockages be considered, interrupted by larger vessels, apparently discordant results may be reached by taking measurements at different points of the system, as, for instance, at the upper or the lower gates of the upper lock, or at one or the other of the end of the flight. This fact is due to the storage capacity of the flight, which, in changing from the setting for a larger lockage to the 350-foot lockage, or the reverse, may admit more water at the upper end than it lets out at the lower end, and vice versa. After operating with the 350-foot lock, it may be necessary to admit additional water into the system to restore levels for a succeeding larger vessel. When the reckoning is made at the upper gates, this additional prism appears separately from the prism used in changing the level of the vessel, since it is passed on to the 550-foot upper lock. When the reckoning is made at the lower gates of the 550-foot upper lock, the prisms appear together when they are first drawn off, instead of later, when the deficiency thus created is made good by draft on the upper pool. The lower end of the upper 1,000-foot lock appears, therefore, the more convenient place to make the reckoning. All water above that barrier is useful in all lockages and hence may be counted as saved to the upper pool. Reckoned as above, the table for down-lockages in the 51,500-foot lock gives prisms of lift as follows:

Gatun lock flight—Condition in series of 350-foot lockages, following 550-foot lockages.

UP-LOCKAGES.

[Area of lock, 40,500 square feet.]

	Levels found after 550-foot lockages.	First 350-foot lockage.			Second 350-foot lockage.			Third 350-foot lockage.			Theoretical.		
		High level.	Low level.	Lift.	High level.	Low level.	Lift.	High level.	Low level.	Lift.	High level.	Low level.	Lift.
	Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	85.00	66.30	18.70	85.00	65.54	19.46	85.00	65.35	19.65	85.00	66.10	18.90
Upper 550-foot lock	85.00	66.30	57.12	9.18	65.54	55.98	9.56	65.35	55.70	9.65	66.10	56.82	9.28
Middle 550-foot lock	57.12	57.12	28.56	28.56	55.98	45.41	10.57	55.70	45.62	10.08	56.82	47.31	9.51
Middle 350-foot lock	28.56	28.56	28.56	00.00	45.41	22.18	23.23	45.62	25.02	20.60	47.31	28.41	18.90
Lower 550-foot lock	28.56	28.56	00.00	28.56	22.18	19.00	3.18	25.02	14.76	10.26	28.41	18.90	9.51
Lower 350-foot level	28.56	00.00	00.00	....	19.00	00.00	19.00	14.76	00.00	14.76	18.90	00.00	18.90

DOWN-LOCKAGES.

[Area of lock, 51,500 square feet.]

	Levels found after 550-foot lockages.	First High level.	First Low level.	First Lift.	Second High level.	Second Low level.	Second Lift.	Third High level.	Third Low level.	Third Lift.	Theoretical High level.	Theoretical Low level.	Theoretical Lift.
Upper 350-foot lock	85.00	85.00	67.82	17.18	85.00	62.48	22.52	85.00	64.84	20.16	85.00	69.39	15.61
Upper 550-foot lock	57.12	67.82	48.43	19.39	62.48	52.26	10.22	64.84	52.32	12.52	69.39	59.65	9.74
Middle 550-foot lock	28.56	48.43	41.78	6.65	52.26	39.45	12.81	52.32	41.29	11.03	59.65	49.66	9.99
Middle 350-foot lock	28.56	41.78	13.98	27.80	39.45	19.39	20.06	41.29	22.40	18.89	49.66	29.82	19.84
Lower 550-foot lock	00.00	13.98	9.30	4.68	19.39	12.90	6.49	22.40	14.90	7.50	29.82	19.84	9.99
Lower 350-foot lock	00.00	9.30	00.00	9.30	12.90	00.00	12.90	14.90	00.00	14.90	19.84	00.00	19.84

For the first, 19.39 × 82,500 = 1,599,675 cubic feet.
For the second, 10.22 × 82,500 = 843,150 cubic feet.
For the third, 12.52 × 82,500 = 1,032,900 cubic feet,
a total for the three lockages of, say, 3,476,000 cubic feet, or an average prism for the down-lockage of 1,159,000 cubic feet. The same result would be reached by considering as lost to the upper pool all water which is drawn from the level +85. If this be done, the three lockages would cost prisms of lift as follows:
For the first, 17.18 × 51,500 = 884,770 cubic feet.
For the second, 22.52 × 51,500 = 1,159,780 cubic feet.
For the third, 20.16 × 51,500 = 1,038,240 cubic feet.
For restoring upper 550-foot lock from +52.32 to +57.12,
4.80 × 82,500 = 396,000 cubic feet,
a total of, say, 3,478,000 cubic feet. In this case the water required to restore the level in the upper 550-foot lock from +52.32 to +57.12, i. e., to the level at which it was found, must be considered, since it passes the upper gates. In the former reckoning it is not considered, since it does not pass the lower gates of the upper lock; but an equivalent amount has been reckoned, which passed down through the lower gates during these lockages, causing the fall in the level in the upper 550-foot lock. It will be seen, therefore, that the fact of considering the water as lost which passes out through the lower gates of the upper lock is equivalent to considering as lost both the prism which is drawn from the upper level to make the lockages and that which is required to restore the level later to that suited to the use of the larger lock.

The greatest available length for down-lockages in the 350-foot lock is obtained by utilizing the space from the upper pair of upper gates, or upper guard gates, to the fender chain above the intermediate gate in the upper lock. This lock has an area of 51,500 square feet, and an available length, measured between the quoins of the upper guard gates and the fender chain, of 370 feet. Practically the same available length can be obtained for a vessel going upstream by using the space between the intermediate gates and the upper gates, since, in case of a vessel so bound, the fender chain would be dropped and the space between this and the intermediate gates would therefore be gained. In case of the upbound vessel, therefore, the 350-foot lock may be assumed to be the chamber between the fender chain above the intermediate gates and the upper gates, both the upper gates and the upper guard gates remaining closed. The chamber thus obtained has an available length of 358.5 feet and an area of 40,500 square feet. The prism of lift is considerably less than in the case of the 51,500-foot lock. More than half the vessels small enough for the 350-foot lock will use this chamber in either direction, and practically all will use it going up. The table is calculated for down-lockages in the 51,500-foot lock and up-lockages in the 40,500-foot lock.

By considering the prisms of lift, it will be seen that for a series of a few small vessels bound down and following each other, the first one finding the flight in readiness for 550-foot lockages, and the last one

leaving it in the same condition as found, the saving by use of the large 350-foot lock instead of the 550-foot lock is as follows:

	Cubic feet.
For three vessels	3,427,000
For two vessels	2,159,000
For one vessel	701,000

A study of the table of 350-foot up-lockages displays a different condition of affairs. Reckoning as lost to the upper level the amount passing the lower gates of the upper 1,000-foot lock, as before, it is found that for the first lockage this prism is $82,500 \times 27.88$, or 2,300,100 cubic feet, the same as for the 550-foot lock, since it is measured by the drop from the original level of the 550-foot upper lock to its low level—i. e., from 85 to 57.12. This is the same as the prism poured from the upper 550-foot lock into the one next below, viz, $80,500 \times 28.56$, and also the same as the amount which must be drawn through the upper gates of the lock, first, to raise the vessel in the 350-foot lock from the low level of that lock to lake level, and, second, to restore the level in the upper 550-foot lock to the level suited to the 550-foot lockage. It follows, therefore, that in passing upward, a single 350-foot vessel, followed immediately by a 550-foot vessel, there is no gain in using the 350-foot lock.

The second and all successively following up-lockages, however, result in material saving.

The total loss through the lower gates of the upper lock which, as stated, is equal to the loss to the upper level, both in raising the boat and in restoring levels in the upper 550-foot lock afterwards, is as follows for the first three up-lockages:

First lockage, $82,500 \times (85-57.12)$	2,300,100
Second lockage, $82,500 \times (66.30-55.98)$	850,400
Third lockage, $82,500 \times (65.54-55.70)$	811,800
	3,969,300

The same result is obtained by making the reckoning at the upper gates of the system, considering the water which must be drawn through the valves there, both to let the vessel up and also to restore the levels for the use of a larger vessel interrupting the series of small lockages. Thus, the first three lockages will draw through the valves at the upper gates an aggregate prism of $40,500 \times (18.70 + 19.46 + 19.65)$ in raising the vessels, and a further amount of $82,500 \times (85 - 65.35)$ in restoring the upper 550-foot lock to the level needed for locking a large vessel. The total of these prisms is 3,962,430 cubic feet, or practically the same as that found when reckoning is made at the lower gates, the difference being due to neglect of figures beyond the second place of decimals.

When the flight is found set for 550-foot lockages, a single vessel can pass up by 350-foot lockages and the flight immediately afterward restored to proper levels for the 550-foot lock without either gain or loss; while to pass a greater number of vessels up and restore the locks to the original condition results in saving as follows:

	Cubic feet.
For three vessels	2,253,000
For two vessels	1,359,000
For one vessel	0

Assuming three vessels as the average length of the series using the small lock, and allowing immediate restoration of level suitable

for 550-foot lockages, the average expenditure per lockage in the 40,500-foot lock is 1,086,000 cubic feet and in the 51,500-foot lock is 1,166,000 cubic feet. In a similar series of up-lockages in the 40,500-foot lock, the average expenditure is 1,323,000 cubic feet. This latter quantity may be held to apply to all 350-foot up-lockages, since, as we have seen, there is no necessity for using the 51,500-foot lock except for vessels bound downward. Assuming that one-half the vessels small enough for the 350-foot lock will require all the space between the upper guard gates and the fender chain when bound down, and that one-half of them can find place between the fender chain and the upper gates, i. e., in the 40,500-foot lock, it appears that one half the down-lockages will take a prism of 1,159,000 cubic feet, while the other half of the down-bound lockages will take 1,086,000 cubic feet, while the up-lockages will all average 1,324,000 cubic feet, these figures being all based upon a series of three small lockages with immediate subsequent restoration of level to that required for the use of the large locks. Under this supposition, the average expenditure in using the 350-foot lock becomes 1,181,000 cubic feet, which will be taken as the average 350-foot lockage prism at Gatun. As stated, this is an artificial prism based upon the assumption that three successive 350-foot lockages will be the average length of a series, and that immediately thereafter the levels are restored to the setting for 550-foot lockages, at which they were originally found.

PRISMS OF LIFT, GATUN.

The prisms of water drawn from the upper pool, i. e., from the lake lying above the upper gates of the chamber, used in each case, are as follows:

	Cubic feet.
For the 1,000-foot lock	3, 543, 000
For the 900-foot lock	3, 446, 000
For the 550-foot lock	2, 300, 000
For the 350-foot lock (assumed average)	1, 338, 000
Theoretical 350-foot, 51,500-foot lock	804, 000
Theoretical 350-foot, 40,500-foot lock	701, 000

GENERAL FORMULA FOR A FLIGHT OF LOCKS, AS BEFORE. CROSS-FILLED.

If we assume that the locks are built as twins and that communication between the corresponding ones can be effected through the middle wall, and if we assume further that one flight of locks is reserved for upward and one for downward bound vessels, it follows that in the former flight the locks will habitually be left full after a passage, and in the latter they will habitually be left at the low level. In consequence, immediately after an upbound lockage it will be practically always possible to pass over from the upper lock of the upbound flight a prism of water to the upper lock of the downbound flight, since the normal condition of the one is complementary to that of the other.

Furthermore, since the first operation of locking a vessel down is to fill the upper lock of the downbound flight from the upper level, it having been left empty by the last passage, it follows that any water drawn into it from its twin is saved to the upper level. On the other hand, it is not always possible to pass water from the upper

lock of the downbound flight, after filling, to the corresponding lock on the upbound flight. The upper lock of the downbound flight is full only when it is just about to function by lowering a vessel to the intermediate level. Conversely, the upper lock of the upbound flight is at its low level only when a vessel is about to be raised to the lake level. Both of these conditions are temporary rather than habitual, and must occur simultaneously in order that water can be passed from the full downbound lock to the empty upbound one with saving of the complete amount possible of transference. In general, this will not be the case. Nevertheless, partial saving can practically always be effected whether the vessel passes downstream or upstream, as will appear hereafter.

Let us suppose that the upper lock in the downbound flight is empty and its twin in the upbound flight is full—the ordinary stages of both when not in use—and let a prism of water of height w be passed from the upbound to the downbound lock; and represent by x the height at which the water surface in the upper upbound lock remains then above the water surface in the middle upbound lock; and represent by y and z the lifts in the middle and lower upbound locks. We have then the equations—

$$(1) \quad x = y\frac{A_1}{A}$$

$$(2) \quad y = z$$

and since w is the vertical distance from the water surface in the upper lock, after cross filling, to the water surface of the lake above—

$$(3) \quad w + x + y + z = H,$$

general equations from which the values of x, y, and z can be derived whenever w and H are known.

Since the upper twin locks are equal in area, they will equalize at the halfway point if the process of cross filling be continued to its conclusion. In that case w is equal to x, or to one-half the original lift of the upper lock, and equation (3) becomes $2x + y + z = H$.

Substituting and reducing we have $y = \dfrac{H}{2 + \dfrac{2A_1}{A}}$.

LARGE LOCKS AT GATUN CROSS-FILLED.

In the Gatun flight the normal fall between pool levels is 85 feet and the value of A_1 and A are known. Substituting in the above equation we have $x = 20.17$; $w = x = 20.17$; $y = z = 22.33$, and the conditions of the water surfaces and lifts are as follows:

	High level.	Lift.
	Feet.	*Feet.*
Upper lock:		
Before cross filling	+85.00	[a] 20.17
After cross filling	+64.83	[a] 20.17
Middle lock	+44.66	22.33
Lower lock	+22.33	22.33
Sea level	0.00	....

[a] To level after cross filling to middle lock.

A vessel ascending with these water levels would require, in passing from the high level of the middle lock to the lake level, a prism with altitude of $(85-44.66)=40.34$; but, at once, after the vessel passes out through the upper gates, the latter can be closed and half of this prism passed over into the twin lock, leaving the upper lock and its twin lock at reference (64.83). The twin will take correspondingly less water from the upper level to fill it for the next down lockage, and a prism with altitude of 20.17 feet has therefore been saved to the upper level. If, now, when the upper lock of the downbound flight is next filled from the upper level for lockage, it should be brought about that, when the time comes to open the valves and lower the vessel through the first lift, the upper lock of the upbound lockage should just be set ready for raising a vessel to the upper level, a complete equalization between the two could again take place with resulting saving in the upbound flight of one-half the total prism. If this double process of cross filling could be continued, the levels in both flights would shortly become those given just above, and the upbound and downbound lockages would each be accomplished with the expenditure of lockage prism of the area of the upper lock and with an altitude of 20.17 feet, this being the prism sent down through the lower valves of the upper lock. On page 78, ante, it is seen that the normal 1,000-foot lockage without cross filling costs a prism similar in base but with altitude of 26.46 feet. The total saving by cross filling in each lockage would therefore be a prism with altitude of (26.44 feet − 20.17 feet) = 6.27, or 24 per cent of the normal lockage expenditure.

The ruling draft is that over the lower sill of the upper lock, reference +(15), or 44.66 feet − 15 feet = 29.66 feet at normal levels.

The conditions of levels and lifts at high and low water are as follows:

1,000-FOOT LOCK, CROSS-FILLED.

	High level.	Lift.	Depth over lower sill.
Lake at +87, sea at +1:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+87.00	20.40	....
After cross filling	+66.60	20.40	31.20
Middle lock	+46.20	22.60	37.18
Lower lock	+23.60	22.60	42.33
Sea	+ 1.00	....	....
Saving 26.76−20.40=6.36 feet, or, say, 24 per cent.			
Lake at +87, sea at −1:			
Upper lock	+87.00	20.88	....
After cross filling	+66.12	20.88	30.24
Middle lock	+45.24	23.12	35.70
Lower lock	+22.12	23.12	41.33
Sea	− 1.00	....	....
Saving 27.38−20.88=6.50, or, say, 24 per cent.			
Lake at +82, sea at +1:			
Upper lock	+82.00	19.22	....
After cross filling	+62.78	19.22	28.56
Middle lock	+43.56	21.28	35.86
Lower lock	+22.28	21.28	43.33
Sea	+ 1.00	....	....
Saving 25.20−19.22=5.98 feet, or say, 24 per cent.			
Lake at +82, sea at −1:			
Upper lock	+82.00	19.69	....
After cross filling	+62.31	19.69	27.62
Middle lock	+42.62	21.81	34.39
Lower lock	+20.81	21.81	41.33
Sea	− 1.00	....	....
Saving 25.82−19.69=6.13 feet, or, say, 24 per cent.			

The 900-foot lock, which is a particular case of the 1,000-foot lock, yields practically similar results for cross filling. At normal levels, with lake at +85 and the sea at 0, the levels and lifts become as follows:

	High level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
Upper lock	+85.00	21.08	....
After cross filling	+63.92	21.08	27.84
Middle lock	+42.84	21.42	35.00
Lower lock	+21.42	21.42	42.33
Sea	0.00	....	....
Saving 28.02−21.08=6.94 feet, or, say, 25 per cent.			

At the high-level condition of +87 in the lake and +1 in the sea the ruling draft is 29.36 feet, while at the minimum levels of lake at +82 and sea at −1 the ruling draft is 25.84. In all cases the saving is about 25 per cent.

As stated, this total expenditure involves continuous and equal cross filling between the two upper locks, and implies, therefore, an equal number of vessels in both directions, and care in so timing their passage into the upper locks that the full saving can be accomplished. If we consider, however, that there are more vessels moving in one direction than in the other, it is evident that this entire saving can not take place. It may be shown, however, that a considerable saving is yet possible, although not equal to the maximum.

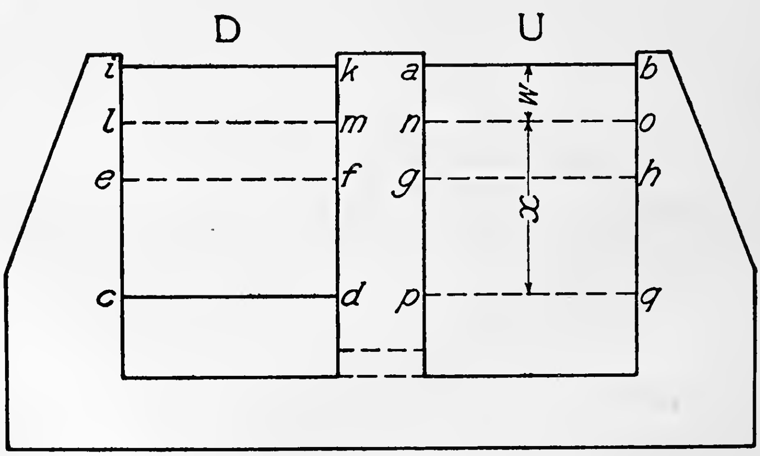


Fig. 4

Let the foregoing figure represent a cross section through the upper locks and let it be supposed that the lockages are not occurring at regular intervals. After a downbound lockage the level in the lock *D* will be at the low level *c d*, while the characteristic level of *U* when not in use is at *a b*. Let us suppose, therefore, that, after the first upbound lockage, the lock *U* is equalized into *D*, the water level

becoming *e f* and *g h* in the two locks, and let a downbound lockage take place. The downbound lockages will require that the lock *D* be filled from *e f* to *i k* in order to admit the vessel, which can then be sent down the flight under normal conditions with the expenditure of only one-half the normal prism of lift. The upbound flight, however, must be manipulated with the water in the upper lock at level *g h*, 13.22 feet below lake level +85. Thus, while the levels and lifts in the downbound flight will be normal for an uncross-filled lockage, the levels and lifts in the upbound flight will result from equations as follows:

$$(1)\quad 13.22+x+y+z=85$$

$$(2)\quad x=y\,\frac{A_1}{A}$$

$$(3)\quad y=z,$$

or, transforming and reducing—

$$x\left(1+\frac{2A}{A_1}\right)=71.78$$

$$x=22'.33$$

$$y=z=24'.72.$$

The levels and lifts are therefore as follows in the upbound flight:

	High level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
Upper lock	+85.00	13.22	....
After cross filling	+71.78	22.33	[a] 34.45
Middle lock	+49.45	24.72	38.31
Lower lock	+24.73	24.72	42.33
Sea	0.00	....	....

[a] With lake at 80 and sea at −1, the critical depth becomes 31.12 feet.

The expenditure for the up-lockage, i. e., the amount passed down through the lower gates of the upper lock, is therefore a prism 22.33 feet in altitude. The total expenditure is therefore:

Down-lockage	26.44
Up-lockage	22.33
	48.77

But two normal lockages cost $26.44\times2=52.88$ feet. Therefore, using only one flight of locks with the cross-filled levels, something which can practically always be done, we have saved 4.11 feet out of 52.88 feet, or, say, 8 per cent. If, after equalizing the two locks at the level *e f g h*, the upper lock *D* of the downbound flight be filled to lower a vessel before an upbound lockage has been made, and while the level in *U* is at *g h*, a portion of the water in *D* may be transferred to *U*, the water level in the two assuming the position *l m n o*. This we may do frequently, and we can be practically certain of locking under one of these two conditions. It might even be possible that an upbound vessel would not come far enough in its passage to draw upon the upper lock of the flight until the water

in D had been lowered to $c\ d$, the downbound boat had passed and the gates and valves closed behind it, in which case the prism $n\ o\ g\ h$, or even more, might again be restored to the lock D. But even if we assume that both locks are left with the upper levels $l\ m$ and $n\ o$, we shall find a considerable saving. In this case, from the two equalizations, it follows that the height of the prism $a\ n\ o\ b$, which we will call w, is equal to one-third of x, and remaining lift of the upper lock. With this substitution in the previous general equations we finally deduce—

$$x=\frac{H}{\frac{4}{3}+\frac{2A}{A_1}},\ y=z=x\frac{A}{A_1}$$

and the values of the lifts and levels become as follows:

	Levels.	Lifts.
	Feet.	*Feet.*
Upper lock:		
Before cross filling	+85.00	7.99
After cross filling	+77.01	23.97
Middle lock	+53.04	26.52
Lower lock	+26.52	26.52
Sea level	0.00	

The critical depth is 38.04 feet when the vessel is passing from the upper into the middle lock with water level at 53.04 and sill at 15. It can be seen, therefore, that even with this reduced prism of lockage a vessel drawing 38 feet can be passed through, which draft will very rarely be exceeded.

In this assumption, both flights are operated with upper level the same—i. e., in the plane $l\ m\ n\ o$. The conditions of water levels and lifts throughout these flights become, therefore, identical. The upbound vessel draws from the lake a prism in height equal to $a\ p$, or $x+w$. The downbound vessel draws from the lake the prism of a height equal to $i\ e$, or $2\ w$. Each of them draws through the lower gates of the upper lock a prism of height x. The double lockage is therefore accomplished by an expenditure of $31.96+15.98=23.97+23.97=47.94$ feet in height of the upper lock. Two normal lockages cost 52.88 feet (see page 78, ante). It follows, therefore, that this method has saved, say, 10 per cent of the total normal lockage expenditure.

From the foregoing it may be seen that a saving of 8 to 10 per cent can practically always be made by cross filling in the Gatun lock flight, and that a saving of 24 per cent is a possible limit, the critical depth at mean stages being 34.45 to 38.04 feet in the former and 29.66 feet in the latter case.

Should a vessel requiring the full 40-foot depth interrupt the series, it might nullify a part of the saving already made, since it might require the lower locks to be filled to the normal level as well as the full prism to be taken for the upper lockage. It is evident, however, that such interruption of the cycle of low-level lockages will be infrequent and with anything less than 40 feet a saving can always be made.

550-FOOT LOCK AT GATUN, CROSS-FILLED.

An effect can be obtained by cross filling from the 550-foot lock into its neighbor similar to that obtained in case of the full-sized lock, and a similar saving in the Gatun flight varying between 25 and 10 per cent can be made.

The minimum depth under normal levels of lake at +85 and sea at 0, for the cross-filled 550-foot lock, is 27.5 feet when complete cross filling is assumed. At maximum levels of lake at +87 and sea at +1, the critical depth is 29 feet, and at minimum levels of lake at +82 and sea at −1, the critical depth is 25.5 feet. The saving in all these cases, assuming complete cross filling, is 25 per cent. If incomplete cross filling be assumed, as described for the 1,000-foot lock (see page 91, ante), the saving is less, but the depth over the sills becomes very greatly increased.

350-FOOT LOCK AT GATUN, CROSS-FILLED.

Similarly, a saving of about 18 per cent can be made by cross filling between the 350-foot locks when occasion serves. In these cases, while the depth is reduced, it remains considerably in excess of that which a vessel small enough to use this lock would probably require, the critical depth at normal levels of lake at +85 and sea at 0 being 32.2 feet when complete cross filling is assumed, and the series of small vessels is sufficiently long to establish the theoretical sequence of levels.

SINGLE-LIFT LOCK AT PEDRO MIGUEL.

The normal lift at Pedro Miguel is from reference +85 to reference $+54\frac{2}{3}$, or $30\frac{1}{3}$ feet for the larger sized locks. For the 350-foot lock the lift results from equations—

$$x = \frac{A\,y}{B}$$

$$x + y = 30\tfrac{1}{3},$$

in which A is equal to 82,500 square feet and B is equal to 51,500 square feet for the larger 350-foot lock and 40,500 square feet for the smaller. These equations give corresponding lifts of 18.69 for the larger and 20.35 for the smaller lock. The prisms of lift, therefore, are as follows:

	Cubic feet.
For the 1,000-foot lock	4,065,000
For the 900-foot lock	3,750,000
For the 550-foot lock	2,500,000
For the 350-foot lock (larger)	962,000
For the 350-foot lock (smaller)	824,000

DOUBLE-LIFT LOCK AT MIRAFLORES.

1,000-foot lock.—

A = 134,000 square feet.
A_1 = 120,000 square feet, there being no intermediate gate recesses.

With lake at $+55$ and sea at -10, the equations of condition are as follows:

$$x+y=65$$
$$y=x\frac{A}{A_1}, \text{ hence } x=30.71 \text{ and } y=34.29.$$

For lake at $+55$ and sea at $+10$, we have—

$$x+y=45,$$

and y fixed at 18, since, with the coping level assumed at 32 for the lower lock, the water therein can not rise above $+28$ without unduly diminishing the adopted freeboard. Levels and lifts are as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +55, sea at −10:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	30.71	42.62
Lower lock	+24.29	34.29	40.00
Sea	−10.00	....	....
Prism of lift, 134,000×30.71=4,115,000 cubic feet.			
Lake at +55, sea at +10:			
Upper lock	+55.00	27.00	46.33
Lower lock	+28.00	18.00	60.00
Sea	+10.00	....	....
Prism of lift 134,000×27=3,618,000 cubic feet.			

The prism received by the lower lock is $120,000\times 18=2,160,000$ cubic feet. At high tide, therefore, the difference of 1,458,000 cubic feet between these prisms must be wasted. The stage at which wasting must begin is determined by the following equations:

$$x+y=H$$
$$x=y\frac{A_1}{A}=27, \therefore y=30.15.$$

Since high level in the lower lock is fixed at reference $+28$, the entire lift of the double flight is determined by $30.15+27=57.15$, which would correspond to a stage of -2.15. Up to this stage the lower lock will receive the prism from the upper lock without wasting. Beyond this stage more or less water must be wasted, varying from 0, just at this stage, to a maximum of 1,458,000 at the stage of $+10$.

By assuming lift at $+45$, corresponding to high tide, and assuming walls for the lower lock high enough to contain the entire prism of lift at this stage, we find that equalization would take place at reference 33.74, and that with the adopted freeboard the wall would have to be built to reference 37.74, or 5.74 feet higher than is now planned for it. Such an addition to the height of the walls would make a very serious addition to the cost of the lock and would make the gates 87.74 feet high, or nearly 9 feet higher than any others on the canal.

The effect of placing the coping at a lower level than this is, as has been stated, to cause a waste of water. Let us now see how much this waste amounts to.

If we assume the lower lock walls high enough to contain the entire prism of lift of the upper lock at all stages, the average prism of lift would be that due to mean tide and would be found by the following equations:

$$x+y=H=55$$
$$y=x\frac{A}{A_1}$$

This would give $x=25.99$ for the height of the mean prism of lift, and the contents of this prism would be $25.99\times134{,}000=3{,}482{,}000$ cubic feet. The average prism of lift for the lock as planned between the stages -10 and -2.15 is that due to a stage midway between them, and may readily be found to be 3,866,500 cubic feet. This rules while the tide is rising from -10 to -2.15, or through a height of 7.85 feet. At any stage of tide above -2.15 the prism of water drawn from the upper pool at each lockage remains constant, although the portion of this prism which goes into the lower lock and the portion which is wasted vary with respect to each other. During the last 12.15 feet of the tidal rise the prism of lift is 3,618,000 cubic feet. The average for all stages is therefore $(3{,}866{,}500\times7.85+3{,}618{,}000\times12.15)\times\frac{1}{20}=3{,}716{,}000$. Were the walls of the lock carried to $+37.75$, enabling all the prism of lift to be absorbed in the lower lock even at high tide, the average prism of lift would be 3,482,000 cubic feet. The average loss at each lockage, therefore, due to the fact that the coping is placed at reference $+32$, instead of $+37.75$, is the difference between these two prisms of lift, or 234,000 cubic feet, which is about 6.4 per cent of the average prism of lift according to the present design.

1,000-foot lock cross-filled.—The equations are:

$$2x+y=H$$
$$x=y\frac{A_1}{A}$$

Substituting values corresponding to the proper tidal stages for H, we deduce conditions of levels and lifts as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +55, sea at +10:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	14.44	....
After cross filling	+40.56	14.44	44.45
Lower lock	+26.12	16.12	60.00
Sea	+10.00	....	....
Lake at +55, sea at −10:			
Upper lock	+55.00	20.86	....
After cross filling	+34.14	20.86	31.61
Lower lock	+13.28	23.28	40.00
Sea	−10.00	....	....

The cross-filled prism of lift is therefore $\frac{20.86+14.44}{2}=17.65$ feet in altitude, while the height of the average prism of lift without cross filling is 27.75. The saving is therefore a prism 10.10 feet in altitude.

or 36.4 per cent of the prism of lift at a 1,000-foot lockage without cross filling. This entire saving would only be made in case it were possible to cross fill when using both flights. In the case of the Gatun locks we have seen that while we can be practically certain of cross filling always from the upper lock of the upstream flight to its twin after each lockage, we can not be certain of corresponding cross filling from the upper lock of the downstream flight, when full, to its twin. If only one flight, namely, the upstream flight, be used after cross filling, the downstream flight being used for lockages at ordinary levels, it will be found that in the 1,000-foot lock at Miraflores the saving of water in each double lockage is about 16 per cent of the normal double lockage prism—i. e., to lock a vessel up in the cross-filled flight and to lock a vessel down with the flight at normal levels, takes 16 per cent less water than if both up and down lockages were made without cross filling.

900-foot lock at Miraflores.—For normal lockages, the equations here are as before:

$$x+y=H$$
$$x=y\frac{A_1}{A}$$

A being 123,000 and A_1 120,000 cubic feet. By proper substitutions for H, corresponding to the stage of tide, we deduce conditions of levels and lifts as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +55, sea at +10:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	27.00	46.33
Lower lock	+28.00	18.00	60.00
Sea	+10.00		
Lake at +55, sea at −10:			
Upper lock	+55.00	32.10	41.23
Lower lock	+22.90	32.90	40.00
Sea	−10.00		

In this case, as in the case of the 1,000-foot lock, a certain amount of water has to be wasted at the higher stages of the tide. In the 900-foot lock the wasting begins at a stage +0.32—i. e., the lower lock will contain the entire 900-foot lock at practically mean tide. The prism of lift with tide at −10 is 3,951,000 cubic feet. With stage of +0.32, the prism drawn from the upper pool is 3,321,000 cubic feet. The average prism corresponding to stages of the tide from −10 to +0.32 is therefore 3,636,000 cubic feet. While the prism drawn from the upper pool at stages +0.32 and all higher stages is 3,321,000 cubic feet, the part of this prism which goes into the lower lock and the part which is wasted decreases and increases respectively, as the tide rises. The average prism for all stages of tide is as follows:

$(3{,}636{,}000 \times 10.32 + 3{,}321{,}000 \times 9.68) \times 1/20 = 3{,}484{,}000$ cubic feet.

Were the walls of the lower lock high enough to contain the prism of lift at all stages of tide, the average prism of lift would be 3,302,000 cubic feet, making an average loss per lockage of 143,000 cubic feet,

due to the fact that the walls are not high enough to hold the entire prism of lift. The average loss is about 5 per cent of the average lockage prism.

900-foot lock, cross-filled.—The equations are:

$$2x + y = H$$
$$x = y\frac{A_1}{A}$$

With proper substitutions corresponding to stages of the tide we deduce conditions of levels and lifts as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +55, sea at +10:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	14.88	....
After cross-filling	+40.12	14.88	43.57
Lower lock	+25.24	15.24	60.00
Sea	+10.00	....	....
Lake at +55, sea at −10:			
Upper lock	+55.00	21.50	....
After cross-filling	+33.50	21.50	30.33
Lower lock	+12.00	22.00	40.00
Sea	−10.00	....	....

The height of the average prism lost to the upper pool in a cross-filled 900-foot lockage is therefore $\frac{14.88+21.50}{2}=18.19$. The uncross-filled prism has altitude of 28.30 feet. The saving is therefore 10.11 feet in altitude, or, say, 36 per cent of the normal prism. If we consider the saving as possible only in the downstream lock flight, locking with the cross-filled levels in the upstream flight, the downstream flight will be operated with normal levels, while the upbound flight from the upper lock, to which one-half prism has been transferred, would be worked at reduced levels. Between stages of $+0.32$ and $+10$, the lower level of the upper lock of the downbound flight, at which level it will always be left when a vessel passes through, is $+28$. The half prism transferred to this lock from its twin of the upbound flight will, therefore, have an altitude of $\frac{55-28}{2}=$ $13\frac{1}{2}$ feet. Between the stages of $+0.32$ and -10, the low level of the upper lock of the downbound flight varies from 28 to 22.88, averaging 25.44. Between these stages, therefore, the prism transferred averages $\frac{55-25.44}{2}=14.78$. The average prism transferred, therefore, has an altitude of $(13.5\times 9.68+14.78\times 10.32)\times\frac{1}{20}=14.16$. The conditions of levels and lifts in the downbound lock flight are normal, uncross-filled ones. In the upbound flight they are those resulting from locking with the surface of the water in the upper lock, before it is equalized into the lower lock, at reference of $55-13.5=41.5$, at

all stages of tide above +0.32, and with the same surface at $55-\frac{32.12}{2}=38.94$ at the stage of −10. The conditions of levels and lifts in the upbound flight are as follows:

$[13.5+x+y=54.68 \quad x+y=41.18 \quad x=y\times\frac{A_1}{A}]$

	High level.	Lift.	Depth over lower sill.
Lake at +55, —see at +0.32:	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	13.5	....
(after cross filling)	+41.5	20.78	39.43
Lower lock	+20.72	20.40	....
Sea	+ .32	....	....

$[13.5+x+y=45 \quad x+y=31.5 \quad x=y\times\frac{A_1}{A}.]$

Lake at +55, —sea at +10:			
Upper lock	+55.00	13.5	....
(after cross filling)	+41.5	15.55	44.28
Lower lock	+25.95	15.95	....
Sea	+10.00	....	....

$[\frac{32.12}{2}+x+y=65 \quad x+y=49.14 \quad x=y\times\frac{A_1}{A}]$

Lake at +55, —sea at −10:			
Upper lock	+55.00	16.06	....
(after cross filling)	+38.94	24.17	33.10
Lower lock	+24.77	24.77	....
Sea	−10.00	....	....

The prism of lift taken in an up-lockage is therefore 40.23 feet at low water; 34.28 feet at the stage of +0.32, and 29.05 feet at high water, giving an average of $\left[\frac{40.23+34.28}{2}\times 10.32+\frac{34.28+29.05}{2}\times 9.68\right]\times\frac{1}{20}=34.54$. The average up-lockage costs, therefore, a prism of 34.54; the average down-lockage costs 14.16; both together cost a prism with altitude 48.70, while two normal uncross-filled lockages average a prism of $28.30\times 2=56.60$ feet in altitude.

The saving, therefore, by using only one flight cross filled and the other at normal level is 7.9 feet in height of prism, or, say, 15 per cent of the normal consumption. The least depth in the upbound flight, which works at the low level, is 33.13 at low water and 44.27 at high water. In the downbound flight the levels and depths are normal.

550-foot lock at Miraflores—

$$A=82{,}500 \text{ square feet.}$$
$$A_1=120{,}000 \text{ square feet.}$$

$$x=y\times\frac{A_1}{A}$$
$$x+y=H.$$

The conditions of levels and lifts are as follows:

	High level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
High tide:			
Upper lock	+55.00	26.67	46.66
Lower lock	+28.34	18.33	....
Sea	+10.00	....	....
Low tide:			
Upper lock	+55.00	38.52	34.81
Lower lock	+16.48	26.48	....
Sea	−10.00	....	....

The average height of the prism of lift is $\frac{26.67+38.52}{2}=32.60$, containing 2,690,000 cubic feet.

Were the lower lock subdivided by middle gates, so that at mean tide the 550-foot lock would just fill one of the chambers, while above mean tide the entire lower lock would be used, the conditions would be:

	High level.	Lift.
	Feet.	*Feet.*
High tide (using entire lower lock):		
Upper lock	+55.00	26.67
Lower lock	+28.33	18.33
Sea	+10.00	....
Mean tide (using one chamber of lower lock):		
Upper lock	+55.00	27.50
Lower lock	+27.50	27.50
Sea	0.00	....
Low tide (using one chamber of lower lock):		
Upper lock	+55.00	32.50
Lower lock	+22.50	32.50
Sea	−10.00	....

From −10 to mean tide the lower 550-foot prism would be used, making an average lift of 30 feet. From mean tide to high tide the upper lock would discharge into the entire lower lock, with average lift of $\frac{32.60+26.66}{2}=29.63$. The lift of the average prism lost to the upper pool at all stages of tide would therefore be—

$$\frac{30+29.63}{2}=29.81,$$

but the average lift without intermediate gates is 32.59. The saving by using intermediate gates would be 2.78 feet in height of prism, or about 8 per cent of the prism now used. By wasting through the culverts at high stages, instead of leaving the intermediate gates open in the lower lock and allowing the upper 550-foot prism to empty into the entire lower lock, this saving would be increased to about 12 per cent of the present prism, but the operation would be somewhat more complicated, and doubtless the first procedure would be employed.

If the walls of the lock were so high as to absorb at high tide the prism of the upper 550-foot lock in a lower 550-foot lock, the average

height of the prism of lift would be 27.5; but the present normal average prism is 32.60 feet. The consumption of water with the present design is therefore considerably greater than it would be had it been thought possible to raise the walls to the full height necessary to absorb the high-tide prism, and then, in addition, had intermediate gates been used. In this last case the expenditure in the 550-foot Miraflores lock would have been 16 per cent less than it now will be

550-FOOT LOCK AT MIRAFLORES, CROSS-FILLED.

By process similar to that described in the 900-foot Miraflores upper lock, the conditions of levels and lifts are found as follows:

	High level.	Lift.	Depth over lower sill.
Lake at +55, high tide=(+10):	*Feet.*	*Feet.*	*Feet.*
Upper lock	+55.00	16.75	....
After cross filling	+38.25	16.75	39.83
Lower lock	+21.50	11.50	....
Sea	+10.00	....	....
Lake at +55, low tide=(−10):			
Upper lock	+55.00	24.20	....
After cross filling	+30.80	24.20	24.93
Lower lock	+ 6.60	16.60	....
Sea	−10.00	....	....

The average prism of lift is 20.48 feet in height, whereas the average prism of lift for the lockage with full prism is 32.60 feet in height. Were it possible, therefore, to operate with cross-filled lockages every time, the saving would be 36 per cent in the case of the 550-foot as well as in the larger lockages at Miraflores.

If the lock be operated downbound with full prism and upbound at cross-filled levels, the saving is reduced to about 15 per cent, but the minimum depth is increased, becoming 26.97 feet at low tide in the upbound flight.

350-foot lock at Miraflores:

$$B = 51{,}500, \text{ or } 40{,}500$$
$$A = 82{,}500$$
$$A_1 = 120{,}000$$

The equations of condition are—

$$B\ (x+y) = (A+B)\ y$$
$$A\ (y+z) = (A_1+A)\ z$$
$$x+y+z = H, \ H \text{ being 55 at midstage.}$$

For this condition the theoretical levels and lifts work out as follows for the larger area B:

	Upper level.	Lift.	Depth over lower sill.
Lake at +55, sea at 0:	*Feet.*	*Feet.*	*Feet.*
Upper 350-foot lock	+55.00	26.78	....
Upper 550-foot lock	+28.20	16.77	29.83
Lower lock	+11.50	11.50	....

The theoretical prism of lift is 1,378,000 cubic feet. This condition would be reached after a long series of small lockages. The lock will, however, usually be found set for one of the larger lockages, ordinarily the 550-foot lockage. Assuming it so set and taking, first, the case of the down-lockages, we shall find that the first 350-foot lockage will result in conditions of levels and lifts as follows:

	Upper level.	Lift.
	Feet.	*Feet.*
Upper 350-foot lock	+55.00	20.08
Upper 550-foot lock	+34.92	20.69
Lower lock	+14.23	14.23

the prism of lift being 20.69×82,500 equals, say, 1,707,000 cubic feet. This prism, as at Gatun, is measured at the lower gates of the upper lock and represents the loss to the upper level in case the 350-foot lockage is followed immediately by a 550-foot lockage.

The second down-lockage results in conditions of levels and lifts as follows:

	Upper level.	Lift.
	Feet.	*Feet.*
Upper 350-foot lock	+55.00	25.10
Upper 550-foot lock	+29.00	17.72
Lower lock	+12.18	12.18

the prism of lift being 1,462,000 cubic feet. This prism, as at Gatun, is measured at the lower gates of the upper lock and represents the loss to the upper level in case the 350-foot lockage is followed immediately by a 550-foot lockage.

The third down-lockage results in conditions of levels and lifts as follows:

	Upper level.	Lift.
	Feet.	*Feet.*
Upper 350-foot lock	+55.00	26.36
Upper 550-foot lock	+28.64	16.97
Lower lock	+11.67	11.67

the prism of lift being 1,400,000 cubic feet.

The total expenditure for three down-lockages will therefore be

	Cubic feet.
Third lockage	1,400,000
Second lockage	1,462,000
First lockage	1,707,000
Total	4,569,000

giving an average prism of lift of 1,523,000 cubic feet and a saving of 3,502,000 cubic feet over the expenditure in three 550-foot down-lockages. In this case, as well as at Gatun, there is a considerable saving even if the levels be restored at once after sending a single small vessel down in the 350-foot lock. The saving then amounts to 984,000 cubic feet, and, as has been seen, increases more than proportionally with each succeeding small lockage.

The foregoing expenditure includes the total loss to the upper level by locking three vessels down in the 350-foot lock and leaving the system in condition to receive a succeeding 550-foot vessel.

A result similar to the above may be reached by estimating the prism of lift at the upper gates and adding thereto the prism required to restore levels to the 550-foot lock; thus, at the end of the third lockage the prisms expended at the upper gates would be—

$$51{,}500 \times (20.08 + 26.10 + 26.36) = 3{,}684{,}000 \text{ cubic feet.}$$

To restore the upper 550-foot lock to the level for the 550-foot down-lockage, viz, 22.40, requires the addition of a prism equal to

$$82{,}500 \times (22.40 - 11.67) = 885{,}000 \text{ cubic feet.}$$

The total expenditure therefore for three successive 350-foot lockages followed immediately by a 550-foot lockage, measured at the upper gates, is 3,684,000 + 885,000 = 4,569,000 cubic feet, the same as when measured at the lower gates of the upper lock.

When vessels are locked in the upbound flight, however, the water is found at high level instead of low level, and the conditions here, as at Gatun, vary somewhat from the conditions resulting from down-bound lockages. At the first up-lockage the full lower lock must first be emptied and the vessel brought into it. The upper 550-foot lock, found at +55, is equalized into the lower lock at 0, with resulting combined level of 22.38. The upper 350-foot lock at +55 is then equalized into the 550-foot lock at 22.38, with resulting combined level of 34.92. The height of the first prism of lift is therefore 55.00 − 34.92, or 20.08, and the resulting prism of lift is 1,034,000 cubic feet. To restore the system to the levels required for 550-foot up-lockages would require, in addition to this prism of lift, a prism necessary to raise the water in the 550-foot lock from reference 34.92 to reference 55, a total of 1,650,000 cubic feet. The total expenditure therefore would be 1,034,000 + 1,656,000, a total of 2,690,000 cubic feet, or the normal prism of the lift of the 550-foot lock. To lock a single vessel up, using the 350-foot lock, and immediately to restore levels to those required for 550-foot lockages, costs, therefore, the same amount as to send the vessel through the 550-foot lock. In a series of small lockages, however, there is a great saving. The second vessel finds the levels as left after the first small lockage without restoration, and the second upbound lockage will result in conditions of levels and lifts as follows:

	Upper level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
350-foot upper lock	+55.00	25.10	....
550-foot upper lock	+29.90	15.67	32.56
Lower lock	+14.23	14.23	....

with prism of lift of 1,293,000 cubic feet.

The third up-lockage leaves conditions of levels and lifts as follows:

	Upper level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
Upper 350-foot lock	+55.00	26.36	....
Upper 550-foot lock	+28.64	16.46	....
Lower lock	+12.18	12.18	....

The prism of lift is 1,358,000 cubic feet, and it will cost 82,500× 26.36 cubic feet to restore the 550-foot lock to the condition at which it was found.

The series of three up-lockages using the 51,500-foot lock, with restoration to conditions suitable for 550-foot lockages, has resulted in a total expenditure of 5,859,000 cubic feet, while three 550-foot lockages would have taken 8,070,000 cubic feet.

At Miraflores, as well as at Gatun, the up-lockages will all be made with the smaller of the 350-foot locks, namely, the one with area of 40,500 square feet. In the smaller locks the series of three lockages, with subsequent restoration of levels, take a total amount from the upper pool as follows:

	Cubic feet.
Up-bound	5, 635, 000
Down-bound	4, 195, 000

The corresponding average consumption is therefore 1,859,000 and 1,398,000. Assuming all 350-foot up-lockages and one-half of the down-lockages to be made in the smaller lock, the average consumption is 1,593,000 cubic feet, which is assumed as the 350-foot prism of lift at Miraflores.

EFFECT OF OMITTING INTERMEDIATE GATES IN THE LOCKS.

To investigate the effect upon the water consumption, levels, etc., of omitting certain of the middle gates, let us first suppose the Gatun lock flight to be constructed without intermediate gates in the middle and lower locks. The equations from which the lifts and levels of the 550-foot lockage may then be derived are, as before—

$$x=\frac{A_1 y}{A}$$

$$y=z=\frac{H}{\frac{A_1}{A}+2}$$

in which $A=82{,}500$ cubic feet, $A_1=A_2-120{,}000$ cubic feet. With lake at $+85$ and sea at 0, we have levels and lifts as follows:

	High level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
Upper 550-foot lock	85.00	35.80	....
Middle lock	49.20	24.60	34.20
Lower lock	24.60	24.60	....

The prism of lift is therefore $82{,}500\times35.80=2{,}954{,}000$ cubic feet, increasing the prism of lift of the 550-foot lock as now proposed, viz, 2,300,000 cubic feet, by 28 per cent. Assuming levels found as indicated after a 550-foot lockage, and taking a series of three 350-foot lockages, we find as follows:

Up-lockage, 350-foot lock, $B=40{,}500$ square feet.

A, A_1, and A_2, as before.

	High level.	Lift.		High level.	Lift.
First up-lockage:	*Feet.*	*Feet.*	Second up-lockage—Continued.	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	24.01	Middle lock	39.42	14.82
Upper 550-foot lock	60.99	11.79	Lower lock	24.60	24.60
Middle lock	49.20	24.60	Third up-lockage:		
Lower lock	24.60	24.60	Upper 350-foot lock	85.00	34.30
Second up-lockage:			Upper 550-foot lock	50.70	16.84
Upper 350-foot lock	85.00	30.67	Middle lock	33.86	14.15
Upper 550-foot lock	54.43	15.01	Lower lock	19.71	19.71

At the end of the third up-lockage the total expenditure, measured at the lower end of the upper lock, i. e., the total expenditure for lockages, including restoration of level for a 550-foot lockage, at the close of the series, amounts to $82{,}500 \times (35.8 + 21.47 + 20.57) = 6{,}422{,}000$ cubic feet (see p. 86, ante), giving an average lockage prism of 2,141,000 cubic feet. The corresponding prism where middle gates are present in the lower locks is 1,324,000; hence the omission of the middle gates has occasioned an increase in the 350-foot lockage of 62 per cent over the expenditure in the present design. Taking the case of the down-lockages, we have $B = 51{,}500$, other quantities as before.

	High level.	Lift.		High level.	Lift.
First down-lockage:	*Feet.*	*Feet.*	Second down-lockage—Continued.	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	22.04	Middle lock	35.31	17.65
Upper 550-foot lock	62.96	22.75	lower lock	17.66	17.66
Middle lock	40.21	20.10	Third down-lockage:		
Lower lock	20.11	20.11	Upper 350-foot lock	85.00	30.59
Second down-lockage:			Upper 550-foot lock	54.41	21.79
Upper 350-foot lock	85.00	27.58	Middle lock	32.62	16.31
Upper 550-foot lock	57.42	22.11	Lower lock	16.31	16.31

The total expenditure for the three lockages measured at the lower end of the upper lock is—

$$82{,}500 \times (22.75 + 22.11 + 21.79) = 5{,}498{,}625,$$

or an average for each lockage of, say, 1,833,000 cubic feet. The average down-lockage, similarly reckoned, when intermediate gates are present in the middle and lower locks, has been found to be 1,159,000 cubic feet (see p. 85, ante). The expenditure for the average down-lockage in the 51,500-foot lock is therefore increased about 60 per cent by the omission of the lower gates, practically the same result as found in the case of the 40,500-foot lock.

Taking now the case of the Gatun flight with intermediate gates in the upper and middle lock, but none in the lower lock, we have—

$$B = 51{,}500, \text{ or } 40{,}500$$
$$A = 82{,}500$$
$$A_1 = 80{,}500$$
$$B_1 = 40{,}500$$
$$A_2 = 120{,}000$$

Taking the case of the 550-foot lock first, we find—

$$x = 31.34$$
$$y + z = 32.12$$
$$w = 21.54$$

The levels and lifts are as follows:

	High level.	Lift.	Depth over lower sill.
	Feet.	*Feet.*	*Feet.*
Upper 550-foot lock	85.00	31.34	....
Middle 550-foot lock	53.66	32.12	38.66
Middle 350-foot lock	21.54	0.00	35.12
Lower lock	21.54	21.54	....

The prism of lift is 12 per cent greater than that when intermediate gates are present in all the locks.

Taking, now, the case of the down-lockages in the 550-foot lock, with B equal to 51,500, we find the result of three successive lockages as follows:

	High level.	Lift.		High level.	Lift.
First lockage:	*Feet.*	*Feet.*	Second lockage—Continued.	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	19.29	Middle 350-foot lock	35.14	26.37
Upper 550-foot lock	65.71	21.81	Lower lock	8.77	8.77
Middle 550-foot lock	43.90	7.48	Third lockage:		
Middle 350-foot lock	36.42	27.23	Upper 350-foot lock	85.00	23.27
Lower lock	9.19	9.19	Upper 550-foot lock	61.73	13.13
Second lockage:			Middle 550-foot lock	48.60	13.33
Upper 350-foot lock	85.00	25.30	Middle 350-foot lock	35.27	26.37
Upper 550-foot lock	59.70	11.50	Lower lock	8.90	8.90
Middle 550-foot lock	48.20	13.06			

The expenditures for the three lockages, including the amount necessary for restoration of levels, taken at the lower end of the upper lock, are—

$$82{,}500 \times (21.81 + 11.50 + 13.13) = 3{,}911{,}300 \text{ cubic feet,}$$

an average prism of, say, 1,304,000 cubic feet. The corresponding prism with intermediate gates in the lower lock, as well as in the other two, was found to be 1,159,000 cubic feet. The omission of the intermediate gate in the lowest lock has therefore increased the expenditure for the down-lockages by about 13 per cent. Taking the case of up-lockages in the 40,500-foot lock, we find the results as follows:

	High level.	Lift.		High level.	Lift.
First up-lockage:	*Feet.*	*Feet.*	Second up-lockage—Con.	*Feet.*	*Feet.*
Upper 350-foot lock	85.00	21.02	Middle 350-foot lock	37.18	32.73
Upper 550-foot lock	63.98	10.32	Lower lock	5.43	5.43
Middle 550-foot lock	53.66	32.12	Third up-lockage:		
Middle 350-foot lock	21.54	0.00	Upper 350-foot lock	85.00	23.63
Lower lock	21.54	21.54	Upper 550-foot lock	61.37	11.59
Second up-lockage:			Middle 550-foot lock	49.78	12.55
Upper 350-foot lock	85.00	22.98	Middle 350-foot lock	37.23	27.85
Upper 550-foot lock	62.02	11.28	Lower lock	9.38	9.38
Middle 550-foot lock	50.74	13.56			

The amount of water which has passed the lower valves in the upper 1,000-foot lock, which is measured by the drop from the high level at which the upper 550-foot lock is found at the beginning of each of the successive lockages, and the low level which it assumes in the course of the lockage, is equal to—

$$82{,}500 \times (31.34 + 13.24 + 12.24) = 4{,}687{,}650 \text{ cubic feet.}$$

The prism corresponding to the three successive lockages is 1,563,000 cubic feet, while with intermediate gates in all of the locks it is 1,205,000 cubic feet, an increase of, say, 30 per cent of the smaller prism.

When intermediate gates are present in all the locks of the Gatun flight, the down-lockage prisms in the two 350-foot locks bear to each other the relation of $\frac{1{,}159{,}900}{1{,}086{,}000}$. Assuming the same relation existing between them with intermediate gate omitted in the lower lock, we find that the down prism in the 40,500-foot lock is equal to

$$1{,}304{,}000 \times \frac{1{,}086{,}000}{1{,}159{,}900} = 1{,}225{,}000 \text{ cubic feet.}$$

This gives the average 350-foot prism at Gatun without intermediate gates in the lower lock—i.e., the prism resulting from three successive 350-foot lockages with restoration—as 1,414,000 cubic feet, deduced in the same way as was done for the lock flight with intermediate gates, on page 87, ante. The effect of omitting the intermediate gate in the lower lock at Gatun has therefore been to increase the expenditure in 550-foot lockages by about 12 per cent, and in 350-foot lockages by about 20 per cent. Under the assumptions as to the relative number of lockages in the different sized chambers made in discussing the average water expenditure in pages 85 and 86 of the text, the effect of leaving out the intermediate gates in the lower lock at Gatun would therefore be to increase the total expenditure in the flight by about 10 per cent.

At Miraflores the presence of intermediate gates in the lower lock would diminish the expenditure, according to the present design, in the 550-foot and 350-foot lockages. It would, however, compel considerable care in the use of the 550-foot lock, either necessitating wasting water through the valves at the middle gates above mean tide or requiring that at all stages above mean tide the intermediate gates should be left open. Without one or the other of these precautions, the lock walls would be flooded. Supposing that intermediate gates are used in the lower Miraflores locks, let it be assumed that the chambers into which these gates divide the lower lock are 82,500 and 38,500 square feet in area. Then, after a 550-foot lockage, the levels will be as follows:

	High level.	Lift.
	Feet.	*Feet.*
Upper 350-foot lock	55.00	0.00
Upper 550-foot lock	55.00	27.5
Lower 550-foot lock	27.5	27.5

Taking the case of the up-lockage, we have—

$$B=40{,}500 \text{ square feet.}$$
$$A=A_1=82{,}500 \text{ square feet.}$$
$$B_1=38{,}500 \text{ square feet.}$$

The first vessel going up with the flight found at the levels stated above will result in levels and lifts as follows:

	High level.	Lift.		High level.	Lift.
First up-lockage:	*Feet.*	*Feet.*	Second up-lockage—Cont'd.	*Feet.*	*Feet.*
Upper 350-foot lock	55.00	18.45	Lower 550-foot lock	27.65	8.90
Upper 550-foot lock	36.55	9.05	Lower 350-foot lock	18.75	18.75
Lower 550-foot lock	27.50	27.50	Third up-lockage:		
Lower 350-foot lock	0.00	0.00	Upper 350-foot lock	55.00	18.27
Second up-lockage:			Upper 550-foot lock	36.73	8.97
Upper 350-foot lock	55.00	18.54	Lower 550-foot lock	27.76	8.91
Upper 550-foot lock	36.46	8.81	Lower 350-foot lock	18.85	18.85

Remembering that in each case the prism of lift lost, measured at the lower gates of the upper lock, is equal in altitude to the difference between the high level at which the 550-foot upper lock is found at the beginning of the lockage and the low level attained during the lockage, we have for the altitude of the prisms:

First lockage, $55.00-27.50=27.50$.
Second lockage, $36.55-27.65=8.90$.
Third lockage, $36.46-27.76=7.70$.

The total expenditure in the three lockages, including restoration to the levels needed for a 550-foot lockage, is therefore 3,721,000 cubic feet and the average up-lockage is 1,246,000. In down-lockages we have $B=51{,}500$ square feet, and the other areas as before. The down-lockages result in levels and lifts as follows:

	High level.	Lift.		High level.	Lift.
First down-lockage:	*Feet.*	*Feet.*	Second down-lockage—Cont'd.	*Feet.*	*Feet.*
Upper 350-foot lock	55.00	16.93	Lower 550-foot lock	22.92	7.30
Upper 550-foot lock	38.07	19.04	Lower 350-foot lock	15.62	15.62
Lower 550-foot lock	19.04	6.06	Third down-lockage:		
Lower 350-foot lock	12.98	12.98	Upper 350-foot lock	55.00	19.75
Second down-lockage:			Upper 550-foot lock	35.25	9.82
Upper 350-foot lock	55.00	22.14	Lower 550-foot lock	25.43	8.09
Upper 550-foot lock	32.86	9.94	Lower 350-foot lock	17.34	17.34

The expenditure in the three lockages with restoration is therefore—

$$82{,}500 \times (19.04+9.94+9.31)=3{,}159{,}000,$$

giving the average prism after three lockages of 1,053,000 cubic feet.

If we suppose that the 550-foot lower lock be used up to mid tide and the gates then thrown open and the 550-foot upper lock, after mean tide, spilled into the entire lower lock, which would be the simplest way in which the subdivided lower lock could be operated, the expenditure in 550-foot lockages without the gates is about 8 per cent more than it would be with the gates, as shown on page 99, ante. The 350-foot lockage prism, based on a series of three lockages with

restoration of levels for the 550-foot lockage, would be 30 per cent less than the present figure.

Estimating, as before, that 50 per cent of the total lockages are made in the 550-foot lock and 30 per cent in the 350-foot lock, it is found that the introduction of intermediate gates in the lower lock would save 10 per cent of the present total expenditure in the Miraflores lock flight, or in other words, that the omission of the intermediate gates increases the expenditure in the flight by 11.5 per cent over what it would be were they used.

The water supply of the canal appears to be ample to permit the passage of as many vessels as can use the locks in the twenty-four hours on the basis of the expenditure with the system now proposed—i. e., with the intermediate gates omitted in the lowest lock on one side or the other. To omit them in the lowest lock at Gatun would cause essentially the same additional expenditure of water as to omit them in the lower Miraflores lock, while the actual saving would be less, since the gates and additional masonry at Miraflores are more costly than those at Gatun, owing to their greater height. Furthermore, due to the tidal effect at Miraflores, the introduction of the intermediate gates in the lower lock would give rise to a serious complication which is not occasioned by their presence at Gatun; that is, even in the use of the 550-foot lock it would force care in wasting water at certain stages of the tide. For these reasons I have thought it advisable to omit the intermediate gates in the lower lock at Miraflores, retaining them at Gatun.

SEPARATE LOCKS.

It is interesting to note what the effect upon the water expenditure of the canal would be were the locks separated by levels of considerable extent, instead of being grouped in flights of three at Gatun and two at Miraflores.

Let it be assumed that the difference in level from +85 to 0 is divided into three lifts each of $28\frac{1}{3}$ feet, separated by levels of area so large as not to be affected appreciably by the gain or loss of a prism of lift. The locks, being single, will correspond to the Pedro Miguel lock in dimensions, and each prism of lift for the full-sized lock will be equal to the area of the lock, or 134,000 square feet $\times$ 28.33, each prism therefore would be larger than those in the present design, since in the Gatun and Miraflores flights the lift from the upper lock to the lock next below is somewhat less than 28.33, for the reason that the area of the upper lock is greater than the area of the intermediate or lower lock into which it spills. This circumstance causes additional water expenditure in the single lift lock; it is due, however, to the design of the locks, rather than to the grouping. Were all the locks in the flights of the same size, the prisms of lift in the flight of locks at Gatun and in three separate locks overcoming the same difference in level would be exactly the same.

The total expenditure in passing a vessel completely through the canal will be two prisms of lift from the summit level. At each end of the summit level the prism of lift thus drawn passes down through the next two levels and to the sea, as other boats come up and pass down. The average lift of the sea-level lock would be no greater on the Pacific side than on the Atlantic side. The coping of the lock

on the Pacific side would be placed at approximately the same elevation as the coping of the lower Miraflores lock in the present design, but there would be no necessity for waste of water in that lock at any stage of tide, since the operation would simply mean dropping a prism of lift from a level of +28.33 into a tidal level varying from −10 to +10, and there would be no question of pouring more water into the lock chamber than it could contain. The waste, therefore, which now occurs necessarily in the Miraflores lock, due to tidal oscillation, would be done away with.

The average prisms of lift of the theoretical three level locks would be as follows:

	Cubic feet.
1,000-foot lock	3,796,700
900-foot lock	3,485,000
550-foot lock	2,337,500
350-foot lock	1,095,700

The first three of these prisms are obtained by multiplying the area of the corresponding locks by the lift, 28.33 feet. In the 350-foot lock, however, the case is different. In down-lockages the prism of lift of this lock is 908,700 cubic feet for the 51,500-foot chamber, and 778,200 feet for the 40,500-foot chamber, an average of 893,450 feet, which may be assumed as the down-lockage prism. No variation in this prism occurs even when the series of down-lockages is interrupted by a larger vessel, and a single lock in this respect has the advantage of the flight lock. In the up-lockages, the first of the series would cost just as much as a 550-foot lockage, since the larger of the two chambers is placed at the lower end of the single lock. Succeeding lockages, however, would cost only the same amount as the down-lockage in the smaller chamber—viz, 778,200 cubic feet. Taking, therefore, a series of three lockages following each other, as was done in the consideration of the smaller locks in the flight system, we have the following:

	Cubic feet.
First lockage	2,337,500
Second and third lockages	1,556,400
Total	3,893,900

giving the average up-lockage 1,298,000 cubic feet, and the general average cost of a 350-foot lockage, 1,095,700 cubic feet. Giving the same weights as before to the lock prisms, we have—

$$
\begin{aligned}
3{,}796{,}700 \times 2.5 &= 9{,}491{,}750 \\
3{,}485{,}000 \times 17.5 &= 60{,}987{,}500 \\
2{,}337{,}500 \times 50 &= 116{,}875{,}000 \\
1{,}095{,}700 \times 30 &= 32{,}871{,}000 \\
\hline
& 220{,}225{,}250
\end{aligned}
$$

Average single prism, 2,202,250.

This average single prism is equal to a total expenditure of 25.5 foot-seconds, and the total passage of the canal, therefore, would cost 51 foot-seconds. The single lock, however, has a possible saving, by cross filling, of 50 per cent of its expenditure, and a practically certain saving of 25 per cent. In calculating the expenditures in the flight of locks, the practically certain saving by cross filling was increased by about 25 per cent, as an estimate of the possibilities beyond the certain saving. Following the same rule here, the probable saving due to cross filling in a single lock would be, say, 30 per

cent, which would reduce the expenditure for a complete passage of the canal to 35.7 foot-seconds. In the adopted plan the double lockage, without cross filling, takes 54.6 foot-seconds and the cross-filled double lockage 46.4 foot-seconds. With separate locks, therefore, the double lockage, without cross filling, takes $54.6-51=3.6$ foot-seconds, or, say, 7 per cent less water than the similar double lockage in the adopted plan, and the cross-filled double lockage costs $46.4-35.7=10.7$ foot-seconds, or, say, 25 per cent less water than the corresponding double lockage in the adopted plan.

Comparing the theoretical expenditures in separate locks with the expenditure at Gatun, we find that, assuming the weights given to the different chambers as before, the average double lockage in the Gatun flight would cost 50.6 foot-seconds, or practically the same as that due to single locks. The latter, however, have a practical certainty of saving 25 per cent and a possibility of saving 50 per cent by cross filling, whereas at Gatun the corresponding figures are 8 per cent and 24 per cent. Assuming the actual probable saving in the first case as 30 per cent and at Gatun as 10 per cent, the passage through the separate locks would cost 35.5 foot-seconds, while the passage of the Gatun flight will cost 45.5 foot-seconds. The single-lockage plan would therefore save 22 per cent of the water sent down the Gatun flight under the adopted plan. At Miraflores the conditions, owing to the tidal variation, are different. The Miraflores prism, weighted as before, is 58.4 foot-seconds for a double lockage. This is 7.8 foot-seconds more than the Gatun prism, on account of the wastage, due to tidal oscillations and the omission of the middle gates in the lower lock. The flight at Miraflores, however, can save a larger amount of its water by cross filling, having a possible saving of 35 per cent and a practically certain saving of 16 per cent. Assuming the probable saving as 20 per cent, this increase being in the same proportion as that used before, the total cost of the double lockage is reduced to 46.7 foot-seconds.

From the foregoing it appears that the expenditure of water at Miraflores is somewhat greater than at Gatun. This, however, is due to the different tidal conditions at the two places, rendering waste of water at Miraflores necessary, and to the omission of the intermediate gates in the lower lock, which omission is in part a consequence of the tidal conditions. Under similar conditions the two-lock flight can save more of its water by cross filling than can the three-lock flight, and were the locks on the Pacific side all united in one flight the tidal conditions remaining the same, the expenditure in this flight would be about 10 per cent greater than the expenditures in the adopted plan.

APPENDIX C.

REPORT OF LIEUT. COL. WILLIAM L. SIBERT, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, DIVISON ENGINEER, ATLANTIC DIVISION.

Isthmian Canal Commission,
Department of Construction and Engineering,
Atlantic Division,
Office of Division Engineer,
Gatun, Canal Zone, July 31, 1910.

Sir: I have the honor to submit the following report of work done by the Atlantic division, department of construction and engineering, during the fiscal year ending June 30, 1910:

The work assigned to the division remains as described in the report for last year, except that on July 1, 1909, the construction of buildings was transferred to the quartermaster's department.

A revision of the arrangement of duties, effective September 1, 1909, placed the assistant division engineer, Maj. Chester Harding, Corps of Engineers, U. S. Army, in immediate charge of the designing work of the division and of the division office clerical force.

The construction work comprised within the division, as shown on the accompanying Plate 96, is divided into four parts, as follows:

First. That comprising the excavation of the channel between the Gatun locks and the Atlantic Ocean; the procuring and transporting of stone and sand from Porto Bello and Nombre de Dios, respectively, to Gatun; the transportation of cement from Cristobal to Gatun; the operation of the dry dock and shops at Cristobal; and the construction of breakwaters in Colon Harbor; Maj. Edgar Jadwin, Corps of Engineers, U. S. Army, resident engineer, in local charge, assisted by Capt. Horton W. Stickle, Corps of Engineers, U. S. Army, assistant engineer.

Second. That comprising the construction of the Gatun locks, Maj. James P. Jervey, Corps of Engineers, U. S. Army, resident engineer, in local charge.

Third. That comprising the construction of the Gatun dam and spillway, Maj. George M. Hoffman, Corps of Enigneers, U. S. Army, assistant engineer, in local charge.

Fourth. That comprising municipal engineering work, Mr. Leslie G. Thom, superintendent, in local charge.

Channel Excavation from Gatun to the Atlantic Ocean; Sand, Stone, and Cement Service; Dry Dock and Shops; and Colon Breakwater

[Maj. Edgar Jadwin, resident engineer, in local charge. Capt. Horton W. Stickle, assistant engineer.]

DRY EXCAVATION BELOW SEA LEVEL—MINDI.

Ninety-one thousand five hundred and seventy-two cubic yards of earth and 233,144 cubic yards of rock were excavated by two 70-ton

Bucyrus shovels, working five months, and one model 91 Marion shovel, working four months, an average of 23,194 cubic yards per shovel month.

Considerable trouble was caused by slides. Water in the pit stopped the work of the Marion shovel on November 11, and excavating was suspended on November 20, when the cut was flooded.

At the beginning of the year the deepest excavation was about 32 feet below mean sea level. At the end of the year this had been increased to 42 feet below.

The amount of material moved monthly is shown in the following table:

Mindi.

Month.	Rainfall.	From canal prism.		
		Earth.	Rock.	Total.
1909.	*Inches.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	11.46	17,217	65,161	82,378
August	9.92	27,788	38,461	66,249
September	10.86	19,240	42,197	61,437
October	15.55	24,303	48,340	72,643
November	41.11	3,024	38,985	42,009

The total amount of construction track at Mindi on July 1, 1910, was 3.28 miles.

The "division" cost of excavation is shown in the following table. This includes a small amount of blasting done ahead of the shovels:

Cost per cubic yard, in cents.

Mining	3.84
Loading	13.82
Transportation	19.11
Tracks	11.05
Division office and supervision	1.82
Total	49.64

The cost of dumping was not included, as this was charged to the Gatun dam.

UNLOADING AT MINDI.

At different times during the year a total of 19,975 cubic yards of crushed stone, 16,645 cubic yards of sand, and 2,458 cubic yards of massive stone were unloaded at Mindi. The stone and sand were received in barges from Porto Bello and Nombre de Dios, respectively, and were shipped by rail for use principally in the manufacture of concrete for the locks construction at Gatun.

This work was discontinued on June 11.

DREDGING—OCEAN TO MINDI.

Dredges removed 4,556,375 cubic yards of earth and 399,285 cubic yards of rock from the canal prism; 3,206 cubic yards of earth from approach to Gatun docks; and 69,844 cubic yards of earth and

55,036 cubic yards of rock from the French canal. This work was done by the sea-going dredge *Caribbean*, the 5-yard dipper dredges *Chagres* and *Mindi*, and the French ladder dredges Nos. 1, 5, and 6. The *Chagres* was transferred from Nombre de Dios on December 3, 1909. Her yardage previous to that time is not included in the figures here given.

The fill for the year was 3,492,551 cubic yards, as follows:

	Cubic yards.
0 mile to 1 mile	140,156
1 mile to 2 miles	353,193
2 miles to 3 miles	479,922
3 miles to 4 miles	1,182,225
4 miles to 5 miles	1,217,723
5 miles to 6 miles	119,332

No dredging was done on miles 0 to 1 and 1 to 2 during the year. The only work on mile 2 to 3 was in January and February, when the *Caribbean* dredged from station 2 plus 2,600 to station 3 plus 0.

Of the above total amount of fill, 550,000 cubic yards took place during the high water of November, half of it near the mouth of the Mindi River. The fill is believed to be due to three principal causes, viz, material brought in by floods in the Chagres, flattening of the slopes after the first cut is made, and wave and current action.

It has not been practicable to segregate definitely the amounts due to these causes, but as the fill of 550,000 yards in one month, November, was clearly due largely to material washed in by the Chagres floods, it is thought that the total amount thus brought in during the year was upward of 1,000,000 yards—how much above can not be said. The dam recently constructed across the old Chagres, north of the Gatun dam and east of the spillway, has practically eliminated this source of fill.

The sloughing in of the sides of the cut will become progressively less as the slopes become flatter.

The wave action is very pronounced on the southern half of Limon Bay. Waves of the height usual in the bay do not have much effect on the bottom in the deeper water of the northern half. The shallow water of the northern half lends itself to frequent and easy agitation of the bottom and suspension of the finer material, much of which later settles in the deeper water of the channel. This wave action and the fill due to it are expected to decrease with the construction of the breakwater.

The amount of fill solely due to current action in the bay is not believed to be great, as a number of observations on velocities in normal weather located none as high as 1 foot per second.

As compared with the original material, which included considerable rock and clay, requiring blasting and the use of positive cutters—i. e., dippers and buckets or rotary cutters—for its removal, the fill is in general a light silt removable at the approximate rate of 300,000 yards per month, at a low cost per yard, by the seagoing dredge *Caribbean*.

CRISTOBAL TERMINALS.

One hundred and forty-two thousand six hundred and thirty-eight cubic yards of earth and 104,899 cubic yards of rock were removed

from in front of pier No. 11, and 497,578 cubic yards of earth and 4,350 cubic yards of rock from the approach channel, leading from the Panama Canal to Cristobal Harbor.

MISCELLANEOUS DREDGING.

In addition to the above, 2,000 cubic yards of earth and 2,800 cubic yards of rock were removed from the dry-dock slip, and 78,021 cubic yards of earth and 10,917 cubic yards of rock from Shelter Cove.

The total monthly output of all dredges is shown in the following table:

Month.	From Canal prism.			From accessory works.			Grand total.
	Earth.	Rock.	Total.	Earth.	Rock.	Total.	
1909.	*Cubic yards.*	*Cu. yds.*	*Cubic yards.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	320,413	28,038	348,451	274,783	39,975	314,758	663,209
August	388,282	34,564	422,846	98,414	43,512	141,926	564,772
September	410,574	....	410,574	61,824	21,912	83,736	494,310
October	269,463	45,315	314,778	159,249	2,800	162,049	476,827
November	409,512	48,377	457,889	29,656	3,850	33,506	491,395
December	486,311	2,810	489,121	51,182	16,818	68,000	557,121
1910.							
January	485,752	24,303	510,055	19,122	27,043	46,165	556,220
February	456,340	37,108	493,448	13,290	10,214	23,504	516,952
March	367,557	44,768	412,325	5,646	961	6,607	418,932
April	148,970	41,604	190,574	14,942	5,727	20,669	211,243
May	395,698	51,880	447,578	37,377	500	37,877	485,455
June	417,503	40,518	458,021	27,702	4,690	32,392	490,413
Total	4,556,375	399,285	4,955,660	793,187	178,002	971,189	5,926,849

On July 1, 1909, 40 feet of water could be carried from zero to mile 2 plus 4,700 feet; 30 feet to mile 3 plus 1,150 feet; 20 feet to mile 4 plus 2,200 feet; and 10 feet to mile 4 plus 4,900 feet, the end of the cut.

On July 1, 1910, 37 feet of water could be carried from zero to mile 2 plus 00 feet; 30 feet to mile 4 plus 3,900 feet; 20 feet to mile 5 plus 700 feet; 15 feet to mile 5 plus 1,910 feet, the end of the cut.

Three hundred and sixty-six thousand four hundred and fifty cubic yards of material were blasted in the canal prism, and a large amount of dobies used; also 47,333 cubic yards of material blasted in trench tor proposed dock No. 12.

The average division cost per cubic yard, place measurement, for all material dredged in the prism during the fiscal year was 17.10 cents. This does not include "plant," or general items, but does include mining.

The following table shows the output in the prism by months during the year, and the cost of excavation per cubic yard by the different types of dredges. This cost is division cost, and does not include plant, general items, or mining.

Month.	Suction dredge (seagoing, Caribbean).		Dipper dredges.				Ladder dredges.			
	Earth output.	Cost per cubic yard.	Earth.	Rock.	Total.	Cost.	Earth.	Rock.	Total.	Cost.
1909.	*Cubic yards.*	*Cents.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cents.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cents.*
July	119,519	3.68	....	....	....	....	200,894	28,038	228,932	24.40
August	211,500	4.83	....	....	....	....	176,800	34,546	211,346	24.19
September	123,663	13.85	....	....	....	....	286,911	....	286,911	15.47
October	176,322	4.16	....	....	....	....	93,141	45,315	138,456	36.21
November	334,650	4.17	13,274	....	13,274	23.32	61,688	48,377	109,965	42.16
December	368,600	3.48	7,307	....	7,307	46.92	110,404	2,810	113,214	36.68
1910.										
January	327,360	4.84	5,220	14,095	19,315	31.79	153,172	10,208	163,380	23.22
February	267,840	5.65	37,684	19,061	57,061	25.73	140,602	27,945	168,547	24.59
March	188,790	8.91	21,109	24,291	45,400	21.19	156,697	21,438	178,135	22.62
April [a]	(a)	....	19,137	8,463	27,600	30.80	129,833	33,141	162,974	29.42
May	301,320	5.78	(b)	....	....	....	94,378	51,880	146,258	23.99
June	310,029	6.16	10,311	6,687	16,998	54.94	97,163	33,831	130,994	36.35
Total	2,729,593	....	114,042	72,913	186,955	....	1,701,583	337,529	2,039,112	....
Average cost	....	6.64	....	....	....	36.23	....	....	....	26.42

[a] Repairs; April expenses, $31,042.47. [b] Repairs; May expenses, $12,920.31.

DRILL BARGE "TERRIER."

One of the old French hulls brought down from Frijoles was overhauled and fitted with eight old Star well drills for use as a drill barge. The individual boilers were removed from the drills and steam supplied from the central boiler. The cost of remodeling was approximately $4,000. This barge has worked successfully on subaqueous work. The well drills are placed four on each side of the barge in quincunx order. The two lines of drills are 22 feet apart, and the drills 15 feet apart on each side. She usually drills, loads, and fires eight holes per day. During the dry season it was not practicable to use her in the bay on account of the roughness of the sea. Her division cost of mining for the year has been 4.5 cents per cubic yard for 90,776 cubic yards of rock, and 83,802 cubic yards of overlying earth outside the original shore line, and 8.7 cents per cubic yard if all expense is charged to the rock. The cost was 7.9 cents per cubic yard for 191,872 cubic yards of subaqueous rock inside the shore line.

COST OF DREDGING BETWEEN MINDI AND LIMON BAY.

The average division cost of mining from August, 1908, to June, 1910, has been 7.7 cents per yard for rock and overlying earth which was drilled through, and 16.9 cents per yard if all expense is charged to the rock. One and two-tenths cents of the former figure and 2.6 cents of the latter figure are for dobying. This item will increase later, as it will be necessary to further doby some of the material.

By distributing the cost exclusive of mining proportionately to the number of yards of rock and earth removed by each dredge which handled both, and inversely as the relative outputs of each

when working exclusively in earth and rock, the following approximate segregation of division costs has been made for those dredges which handled both:

	Earth.	Cost per yard.	Rock.	Cost per yard.
	Cubic yards.		*Cubic yards.*	
Dippers	83,150	$0.24	66,226	$0.48
Ladders	1,317,509	.20	303,698	.60
Total	1,400,659	....	369,924	....
Average cost per cubic yard	....	.20+	....	.58

The revised estimate of the original channel excavation between Gatun and the Atlantic Ocean is shown in the following table, which also shows the amounts excavated to date:

[Depth mean low tide, 41 feet.]

Depth M. L. T.	Mile.		Original excavation.			Amounts excavated to date.					Grand total.
						Original excavation.				Fill.	
	From—	To—	Earth.	Rock.	Total.	Earth.	Rock.	Anticipated fill.	Total.		
41 feet.	0	1	337,999	....	337,999	260,027	....	72,918	332,945	277,187	610,132
	1	2	908,512	....	908,512	794,101	....	488,444	1,282,545	1,050,555	2,333,100
	2	3	1,802,413	....	1,802,413	1,238,986	....	209,140	1,468,126	924,578	2,392,704
	3	4	*a*2,784,817	*a* 452,406	3,237,223	1,354,003	91,717	....	1,445,720	2,476,149	3,921,869
	4	5	*a*4,043,234	*a* 907,227	4,950,461	1,920,769	580,796	....	2,501,565	3,273,967	5,775,532
	5	6	2,809,677	2,381,487	5,191,164	1,186,433	1,216,754	....	3,403,187	9,900	2,413,087
	6	6.85	4,781,167	44,076	4,825,243	4,400	....	....	4,400	....	4,400
	Total		17,467,819	3,785,196	21,253,015	6,758,719	1,889,267	770,502	9,438,488	8,012,336	17,450,824

a Figures to be changed, due to more extensive borings.

This estimate includes 9 inches overdepth in wet excavation and 3 inches in dry excavation.

DRY DOCK AND MARINE SHOPS.

The following machines were installed during the year: Hilles & Jones combination punch and shears; Handey lathe, 14 inches by 6 feet; Betts horizontal boring mill; 13-kilowatt Sturtevant generator; 15-horsepower Diehl motor; Fay & Egan mortising and boring machine; Jeanesville air compressor; No. 3 emery grinder; Niles boring mill, 8 feet to 12 feet; Cleveland single-end punch and shears; 3-ton electric crane.

The boiler and blacksmith shops were completed, addition to machine shop finished (including installation of two 10-ton traveling cranes), and an extension to the boiler shop begun. The Gantry crane track was extended 100 feet. Tracks in yard were also extended.

One hundred and twelve pieces of plant were dry docked. Some of the more important work done was as follows:

Altering French ladder dredge into 18-inch pipe-line dredge; 92 per cent complete.

Reassembling 20-inch dredge *Sandpiper;* hull 92 per cent complete, machinery 15 per cent complete.

Old French tug *De Lesseps* repaired and put in commission.

Work on altering French dredge *Nombre* into a 12-inch pipe-line dredge for Nombre de Dios.

Altered French ladder dredge No. 3 into a double-ended clam-shell dredge.

Built girders for Gatun spillway.

Converted 16-inch French dredge into a drill barge.

Fitted dredge No. 86 for burning oil.

Installed towing machines on tugs *Empire* and *Gatun* and on barges 1, 3, 5, 9, and 13.

Overhauled and made repairs to dredging, water transportation, and Gatun dam fleets.

SURVEYS.

In addition to the usual weekly and monthly surveys, the following work was done:

A line run for proposed railroad from Toro Point to Gatun; borings at Kinney's bluff; survey and borings along Naos Island breakwater, and additional borings in Limon Bay in connection with studies for Colon breakwaters.

A survey for a telephone line from Mindi to Toro Point was made. Map and borings were made for the fortification board, and at Nombre de Dios in connection with the sand supply.

Surveys were also made of Salmedina Bank, where a gas and whistling buoy was located; of Cristobal Harbor, Mindi River, French Canal, and at the mouth of the Chagres River.

PORTO BELLO ROCK PLANT.

The quarry has been developed with a single face, having a length of 2,500 feet and a maximum height of 140 feet.

During the year a Canton-Hughes compound, duplex, hydraulic-pressure pump, 18 and 28 by $13\frac{3}{4}$ by 18, was installed for stripping, etc. It is outside-end packed, pot-valve pattern, with independent jet condenser. It works under a steam pressure of 150 pounds, and has a capacity of 1,500 gallons sea water per minute against a water pressure of 250 pounds.

The main pipe line over the hill and through the quarry is 10-inch extra-heavy galvanized, having 4-inch lateral connections every 150 feet. Special $2\frac{1}{2}$-inch hose, with nozzles 1 inch, $1\frac{1}{4}$ inches, and $1\frac{1}{2}$ inches, are played on the material, which is sluiced into the bay.

Two 185-horsepower boilers, one dynamo and engine, and one condenser and pump were also installed.

The wireless station was put in operation, wharf extended, and work on underpinning of front row of posts under shipping bin nearly finished. A new storehouse, Young Men's Christian Association clubhouse, and a commissary were erected during the year.

In blasting operations, 60 per cent dynamite was generally used; the charge varied, depending on the spacing of holes and visible faults. The holes were drilled with $3\frac{5}{8}$-inch tripod drills, 6 to 14 feet apart, vertical, toe and breast holes. Charges ordinarily ran from 15 to 50 pounds. More was used per hole in the toe holes than in down holes. Maximum depth of vertical hole is 24 feet.

The twelve-hour working day was increased to sixteen hours on December 27.

Maximum average hourly output for a month was March, 191 cubic yards.

Maximum sixteen-hour day's output was on June 13; 3,660 cubic yards of crushed rock were produced. On January 22, 4,090 yards were crushed in twenty-two hours.

The maximum month's output was June, 74,184 cubic yards.

The operating cost of procuring crushed rock at Porto Bello since the new system of cost keeping was established, January 1, 1910, has been as follows. This does not include plant arbitrary.

Comparative statement—Porto Bello quarry.

	Jan.	Feb.	Mar.	Apr.	May.	June.
Quarrying:						
Stripping	$0.0248	$0.0534	$0.0400	$0.0376	$0.0378	$0.0233
Drilling	.1454	.0983	.1050	.0694	.0634	.0556
Blasting	.2833	.3361	.3062	.2588	.2894	.2999
Loading	.2402	.1661	.1557	.1520	.1538	.1065
Transportation	.1387	.1277	.1073	.0943	.1062	.0860
Tracks	.1039	.0763	.0619	.0580	.0372	.0334
Power	.0620	.0461	.0277	.0318	.0578	.0462
Maintenance of equipment	.0607	.0652	.0664	.0534	.0618	.1500
Total	1.0590	.9692	.8702	.7553	.8074	.8009
Crushing:						
Operation of crushers	.0441	.0733	.0586	.0578	.0597	.0434
Stone bins and conveyors	.0425	.0598	.0327	.0440	.0374	.0344
Power	.0694	.0524	.0346	.0347	.0526	.0489
Maintenance of equipment	.0776	.0531	.0394	.0442	.0407	.0895
Total	.2336	.2386	.1653	.1807	.1904	.2162
Division expense	.0545	.0859	.0892	.0781	.0926	.1064
Water transportation:						
Operation of tugs and barges	.2205	.1953	.1980	.1420	.1605	.1076
Maintenance of equipment	.1289	.0968	.0876	.0262	.0543	.0231
Total	.3494	.2921	.2856	.1682	.2148	.1307
Unloading barges and transporting to rock pile, Gatun	.3782	.5040	.3342	.3267	.2572	.1848
Grand total cost	2.0747	2.0898	1.7445	1.5090	1.5624	1.4390
Output ... cubic yards	59,122	61,136	69,565	71,963	68,949	74,184

PROCURING SAND AT NOMBRE DE DIOS.

A track system and trestle were installed and a water supply completed. The dredge *Nombre* sank in September, and was raised in November. She was converted into a 12-inch pipe-line dredge, and commenced pumping March 1, 1910. At the close of the year she had dug a shallow channel to a point in the rear of the hotel, and is expected to continue in this direction until she reaches the thick deposit of sand in the town.

Clam-shell dredge No. 3 commenced operations in October.

On March 14, 1910, permission was obtained from the Panamanian government to remove a part of the native houses and huts in the village of Nombre de Dios to a point just behind the town, in order that the sand might be removed.

On April 8 a fire occurred which destroyed 73 buildings, principally thatched cane huts. These are being replaced by new buildings in the rear of the town, and the sand in the burned area will be excavated by the dredges.

During the year 186,913 cubic yards of sand were obtained and delivered at Gatun. Of this amount, 54,390 cubic yards were obtained by the pipe-line dredge *Nombre*, 13,632 cubic yards by the 1½-yard clam shell, temporarily mounted on a barge, 4,040 by dredge No. 3, and 109,841 by the locomotive cranes. In addition, dipper dredge *Chagres* dredged 82,850 cubic yards, and dredge No. 3 approximately 8,350 cubic yards, in developing a channel to the sand deposit. The *Chagres* also rehandled 17,052 yards and the 1½-yard clam shell 5,000 cubic yards of sand dug by the cranes.

The operating cost of procuring sand at Nombre de Dios, since the new system of cost keeping was established, January 1, 1910, has been as follows (this does not include plant arbitrary): The operation of the clam-shell dredge No. 3, which has been largely engaged on development work, was charged against the output of the cranes in January and February, and against pipe-line dredge in March, April, May, and June.

Comparative statement—Nombre de Dios.

	Jan.	Feb.	Mar.	Apr.	May.	June.
Dry excavation:						
Loading by crane	$0.2035	$0.2875	$0.3178	$0.2246	$0.3269	$0.4201
Maintenance of equipment	.0207	.0586	.1839	.0554	.1086	.1808
Dredging excavation:						
Operation dredge Nombre	....	....	.1131	.2627	.3230	.2397
Operation dredge No. 3	.0670	.0358	.0706	.1113	.1552	.1537
Maintenance of equipment	.0202	.0261	.1359	.0823	.1817	.1819
Local cost	.3114	.4080	.4128	.3518	.5273	.5857
Division expense	.0630	.0707	.0399	.0465	.0644	.0865
Water transportation	.3020	.3402	.3265	.2271	.2296	.1890
Maintenance of equipment	.1794	.2878	.1754	.0838	.0765	.0260
Unloading barges and transporting sand to pile at Gatun	.2549	.4026	.2421	.3236	.3080	.2086
Grand total	1.1107	1.5093	1.1967	1.0328	1.2058	1.0958
Output:	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
Crane	15,746	18,400	16,785	19,595	13,284	10,644
Dredge	....	....	16,009	13,474	9,200	15,707
Total	15,746	18,400	32,794	33,069	22,484	26,351

WATER TRANSPORTATION.

In connection with this service, plant steamed 80,000 miles, handled 6,600 barges, and carried 29,000 passengers, approximately.

During the year the tug *Empire* was added to the fleet, and four mud scows were converted into stone barges. Two of these have since been returned to the dredging service.

COLON BREAKWATERS.

The location of the west breakwater was approved March 10, 1910. A considerable amount of preliminary survey work for tracks, water supply, etc., was completed, a harbor dredged in Shelter Cove, about 100 acres cleared, 26,904 linear feet of drilling done, 27,610 pounds dynamite used, 3,500 linear feet of pipe line connected, and work started on the reservoir. Two small wharves were completed, and 85 linear feet of permanent dock finished.

At the close of the fiscal year nearly all of the men were in new quarters, and the mess halls completed. Work was well along on the three type 14's, two type 18's, and one type 27.

Gatun Locks.

[Maj. James P. Jervey, resident engineer, in local charge.]

EXCAVATION.

An average of approximately three and one-half shovels and two cranes has been employed in excavation work during the year.

The shovel excavation in the forebay, upper lock, and middle lock was completed before the close of the year. All channeling in the curtain wall, upper lock, and middle lock was also completed.

The trench evcavation in the upper lock and curtain wall was completed, and the trench excavation in the middle lock was 45 per cent completed.

In the lower lock, exclusive of the approach walls, approximately 375,000 cubic yards remain to be removed.

The shovel excavation in the middle of the lower lock is now 33 feet below sea level.

As the excavation has progressed the theoretical profiles of rock strata, as determined by borings, have been confirmed.

It has been found unnecessary to construct the cofferdam at the north end of the lower lock which, when excavation first started, was thought to be probably necessary.

Good rock has thus far been found in all parts of the lower lock, except in the extreme northeast corner, where the indications are that it will be necessary to go somewhat deeper in order to secure rock than the normal height of lock walls and depth of lock would call for.

It is thought that the shovel excavation for the locks, exclusive of the approach walls, will be finished within six months.

The progress of the lock excavation is shown on the accompanying Plate 97, which indicates the original condition of the ground and shows graphically the amounts excavated up to the close of the fiscal year, and the amount remaining to be excavated.

The total amount of excavation, including auxiliary work, is shown in the following table:

	Cubic yards.
Work excavation:	
Dry—	
Earth	1,425,085
Rock	2,540,614
Total	3,965,699
Wet, earth and silt	435,178
Auxiliary excavation:	
Dry—	
Earth	194,385
Rock	11,288
Total	205,673
Wet—	
Rock	42,975
Earth and silt	397,872
Total	440,847
Grand total	5,047,397

PLANT.

At the close of the fiscal year 1908–9 the unloading cableways were in partial operation. During the past fiscal year all parts of the plant were gradually brought up to the normal capacity.

Concreting was started on August 24, 1909, and each month since that date has shown a satisfactory increase in output.

The erection of the steel tower forms for the lock walls was commenced in October. These forms have been entirely satisfactory.

The power plant has been operated satisfactorily and economically. A marked decrease in the cost of power is shown since the beginning of the work. In addition to supplying power for the work connected with the locks, power is being supplied from this plant for the relay pumps on the dam, for the Gatun pumping station, for Gatun lights, and for power and lights in Cristobal.

The total output for the plant in kilowatt hours for the fiscal year is 5,433,516, at a total cost of $144,065.80, giving an average of $0.0265 per kilowatt hour. This includes a plant charge of $0.0088 applied to the output since January 1, 1910 (4,314,586 kilowatt hours), which is based on the absorption of the entire plant cost during the estimated time of operation of the plant.

The power is sold to consumers at actual cost.

In October, 1909, it was determined to erect an auxiliary steam-driven plant at the south end of the locks. This plant was put into operation late in December, 1909, and has turned out 104,422 cubic yards for the fiscal year, as follows:

	Cubic yards.
December, 1909	346
January, 1910	9,569
February	13,968
March	18,078
April	16,316
May	21,193
June	24,952
Total	104,422

CONCRETING.

The concrete work was actually started on August 24, 1909. Between that date and June 30, 1910, a total of 513,802½ cubic yards have been laid, as follows:

1909.	Cubic yards.
August	1,298
September	12,294
October	29,378
November	30,270
December	42,832
1910.	
January	54,136
February	55,696
March	60,997½
April	63,227
May	74,273
June	89,401
Total	513,802½

The mass of the concrete is composed of 1 part of cement, 3 parts of sand, and 6 parts of broken stone. A richer facing mixture, consisting of 1 part of cement, 2 parts of sand, and 4 parts of stone, is used around the main culverts. Finished horizontal surfaces consist of a mortar of 1 part of cement and 3 parts of sand.

Collapsible steel forms have been used throughout for the main and lateral culverts, and have been satisfactory and economical.

In order to cheapen the cost of the concrete, and to expedite the work, large stone, procured generally from Culebra cut, and to a small extent from Porto Bello, has been imbedded in the concrete.

PUMPING.

The difficulty of handling the water in the lock excavation has, of course, increased as the excavation progressed.

During the heavy rains in November and December, 1909, the pumps at the north end of the locks were unable to handle the inflow and the lower lock became partially flooded, shutting down the shovel work for a period of one week. With this exception, there has been no delay due to rainfall, although the past year has been an unusually wet one.

In order to provide for the next rainy season, two additional 12-inch pumps, each provided with a 200-horsepower motor, have been ordered, and it is believed that after they are installed it will be possible to handle the heaviest recorded rainfall. The pumps used are direct connected to 220-volt induction motors.

For pumping out culverts and isolated holes, small 3-inch, 4-inch, and 6-inch pumps will be employed. Of these pumps, only the 6-inch had been received and installed at the end of the fiscal year.

SETTING TEMPERATURES IN THE CONCRETE WALLS OF THE LOCKS.

In order to determine the setting temperature of concrete in large masses, thermometers were embedded in the middle and side walls, at the points indicated in Plate 98.

These thermometers were connected with a galvanometer which was placed in the office of the resident engineer. This galvanometer is graduated in centigrade degrees, and is arranged for seven different circuits or thermometers. Each circuit is controlled by means of a push switch, so arranged that when one of the switches is closed all other switches are opened. This automatic opening arrangement makes it impossible to have two or more thermometers thrown onto the recording instrument at the same time. In addition to the testing circuits, a standard resistance is connected with the galvanometer by a testing switch. An adjustable resistance is also provided, in order to adjust the galvanometer to a full-scale deflection. The galvanometer has also an adjustment for setting the galvanometer needle at zero when the switches are all opened.

The thermometers are simply fine wires of high resistance, wound into spirals, in water-tight glass tubes, protected by a steel casing. These thermometers are connected by a lead-covered copper cable with the galvanometer already described.

The electric current for the instrument is supplied from two storage cells, whose electro-motive force is practically 2 volts each.

The thermometers were embedded in the concrete, at the positions shown in the sketch, as fast as the concrete reached the successive heights. Before being embedded they were calibrated by comparing them with 12 mercury thermometers in an oil bath. This comparison was made after all the connections had been completed and the resistance thermometers were ready for placing in the concrete. Temperature correction curves were plotted from these readings.

The principle of the thermometer depends on the rise of resistance due to rise of temperature. As the temperature of each element rises, due to the setting of the concrete, its resistance rises, and the galvanometer is graduated in degrees corresponding to the temperature of the thermometer.

The variations in temperature at the several points of the wall monoliths during the process of setting are shown by curves in Plate 98.

BACK FILL.

A track for commencing the back fill has been constructed along the east wall, and grading for a track along the west wall commenced. The filling will be started soon after the close of the fiscal year.

A selected impervious fill will be used from the south end of the locks to the intermediate gates of the upper lock. From these intermediate gates north a selected fill of hard rock, 6 or 8 feet deep, will be placed at the bottoms of the walls; above this hard rock miscellaneous material will be used.

By using an open fill below the intermediate gates, it has been possible to reduce the thickness of the walls in the middle and lower locks.

APPROACH WALLS.

The foundation for 150 feet of the south-approach wall, beyond the opening of the center-wall culvert, has been put in. The fill for the remainder of this wall, extending over the low ground to the south of the main line of the railroad on the south toe of the dam, is 90 per cent complete, and the driving of test piles in this foundation will commence at an early date. The type of construction for the approach wall above the foundation has not yet been definitely settled. The material to be excavated for the north approach to the locks will be removed in large part by a hydraulic dredge, which will work its way into position by making a narrow cut from the old east diversion. The water necessary for the flotation and operation of the dredge will be excluded from the excavation of the lock by the construction of a wooden barrier, supported by the concrete floor and walls at the extreme north end of the lock proper. These masonry constructions will be built for this purpose, in advance of the regular order, and the excavation required for them will be completed by steam shovels before the dredging operations are commenced. After the dredge has removed all of the softer material included within the area required, it will be withdrawn, a dam will be built across the narrow channel made by the dredge between the excavation and the east diversion, the water will be pumped out, and the remaining hard material, which will probably be encountered from 35 to 40 feet below sea level, will be removed by steam shovels.

GENERAL.

The close of the fiscal year finds the upper lock well advanced, and construction started in the lower lock.

A graphical section of the progress of concrete construction in the locks is shown on the accompanying Plate 99.

The indications for the next fiscal year are that from 80,000 to 85,000 cubic yards will be laid per month. At this rate the close of the next year should find the concrete work in the upper and middle locks practically completed.

A summary showing the amounts of work accomplished during the year is attached (Exhibit 1).

Gatun Dam and Spillway.

[Maj. George M. Hoffman, assistant engineer, in local charge.]

GATUN DAM.

Prior to January, 1910, operations connected with the construction of the dam were confined almost entirely to the section east of the spillway—the necessity of carrying the Chagres River through the west diversion, making it impracticable to extend operations on the west section, except for the construction of trestles along the toes and the filling of several small dumps.

With the subsidence of the floods of the wet season, preparations were made to extend construction over the whole length of the dam. The west diversion was closed April 25, thus turning the Chagres River through the spillway. By the end of the year the north toe (west) had been carried to an average elevation of +30, and the south toe (west) to an average elevation of +35. During the last two months three dredges were engaged pumping hydraulic fill into the west section, two from the south side and one from the north side.

In the east section, construction by both wet and dry fill was actively prosecuted except for the last two months, during which nearly all available material was utilized in making the west section secure against floods. On June 28, a fourth dredge, No. 86, having been received from the contractors, was put to work pumping into the east section. Beginning the last week in January, the three dredges pumping into the east section were successively connected with relay pumps, which increased their output to near the maximum previously attained with low lift and comparatively short pipe line. By the end of the year the north and south toe (east) had reached an average elevation of +65, and the hydraulic fill between an average elevation of +51.

Statement of the estimated quantities of dry and wet fill placed is as follows, showing the dam to be 42 per cent completed:

Material.	Prior to July 1, 1908.	July 1, 1908-9.	July 1, 1909-10.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
Dry fill	462,297	1,781,325	2,577,234	4,820,856
Wet fill		720,047	2,933,075	3,653,122
Total	462,297	2,501,372	5,510,309	8,473,978

Note.—Yardage of dry fill has been obtained by car or place measurement, plus 25 per cent swell; of wet fill, by borrow-pit measurement, less losses, ascertained by cross section when practicable, otherwise estimated.

Plate 100 shows sections of the dam east and west of the spillway, with progress made during the year indicated thereon.

In connection with the building of the dam the following preparatory and other work was performed:

(*a*) The west valley was prepared for the reception of hydraulic fill by clearing; by stripping off the top soil containing roots, etc.; by excavating a cut-off trench along the axis, and a bonding ditch along the foot of the western ridge; and finally by plowing up the low-lying areas. Similar work was continued in the east valley in advance of the hydraulic fill. This work involved the excavation of 111,685 cubic yards, extending over an area of 62 acres.

(*b*) An area of 138.45 acres south of the dam—mostly covered by a heavy growth of large trees—was thoroughly cleared and grubbed. This is the area over which dredges Nos. 82 and 85 will work in making hydraulic fill. A large force was required to accomplish the required results before the lake formed by closing the west diversion covered all the low ground in this vicinity. An area of 51.36 acres was cleared and grubbed in advance of the dredges working north of the dam.

(*c*) Trestles aggregating 7,486 feet in length were constructed, requiring the driving of 2,269 piles.

(*d*) Drainage systems for carrying off the surplus water from the hydraulic fill were installed in the east and west valleys.

(*e*) Track laid amounted to $23\frac{1}{3}$ miles.

GATUN SPILLWAY.

Excavation during the year amounted to 127,610 cubic yards. Most of this was difficult work on account of shallow cuts, contracted space, interference by rain and floods, etc. Excavation to elevation −2 for the foundation of the spillway dam was completed, except at the extreme end; that for the curtain and side walls and for the floor was fully completed, a large proportion of hand work being required in final preparation of foundations for concrete. Including work of previous years, excavation amounts to 1,426,332 cubic yards, and is 94 per cent completed.

Concrete placed during the year amounted to 53,632 cubic yards, making a total of 84,096 cubic yards. By April 25 the side walls, floor, and curtain walls were completed, and the foundation of the dam was sufficiently advanced to warrant turning the Chagres River through the spillway by closing off the west diversion; this was done, and the water in Gatun Lake raised in a few days to a normal elevation of +15, flood waters since having given a maximum elevation of +19.2. Concrete construction is 34 per cent completed.

Over two months were lost on spillway construction, owing to the extreme floods of November and December. Protection levees had been constructed across the upper and lower ends, but it was considered advisable to cut the upper one to save the Gatun waterworks from flooding, and to limit the time during which the main line of the Panama Railroad was out of service.

After turning the Chagres River through the spillway, work was continued excavating for and constructing the approach walls of the spillway dam.

SPILLWAY BRIDGE.

To provide uninterrupted communication for material trains to the west section of the dam, a 6-span steel bridge, on concrete piers, was constructed across the spillway—it being probable that great floods, carrying heavy drift, will carry away the pile trestle crossings heretofore utilized.

Construction was begun in March. The piers were completed and four spans, including the central 100-foot truss, placed by April 25, when water began to flow through the spillway; the remaining two spans were placed as soon as received, in May. Track connections with the north and south toes of the dam, both east and west of the spillway, are practically completed, only a small amount of excavation and track work remaining to be done.

SPILLWAY—MINDI LEVEE.

The great floods of last November and December, which covered all the low areas between Gatun and the sea, led to the adoption of a more extensive project than had been previously contemplated for the protection against floods, not only of construction operations, but of the sea-level section of the finished canal.

Construction of a high, substantial levee, $1\frac{1}{2}$ miles long, extending from the Spillway Hill to the Mindi Hills was authorized. To the end of the year 126,002 cubic yards were placed, making the levee 90 per cent completed.

Plate 96 shows the location of this levee, connecting the hills and forcing the flow, now established through the spillway, to sea, through the original channel of the Chagres River.

MUNICIPAL ENGINEERING.

[Mr. L. G. Thom, superintendent, in local charge.]

On July 1, 1909, the building construction work in the Atlantic division was turned over to the quartermaster's department, with the exception of the construction of the commissary and power plant at Gatun, and the boiler and machine shop at Cristobal; these buildings were completed by this division in August, 1909.

GATUN WATERWORKS.

PUMPING STATION, GATUN RIVER.

This station was in operation from July, 1909, to May 28, 1910. Early in the year the installation of the multistage turbine pump was completed, and the pump was put into operation in September. An additional steam pump, with a capacity of 600 gallons per minute, and a 60-horsepower locomotive boiler were installed; this pump displaced the single-action Knowles pump, which was in bad condition.

In November and December, 1909, considerable difficulty was experienced at this station owing to freshets in the Chagres River. On November 14 the Chagres River rose to elevation 17, or 2 feet from the top of the wall around the electrical pump. In order to keep this pump in operation a wooden bulkhead was constructed to ele-

vation 26. The well was then kept dry by hand pumping and the electrical pump kept in operation throughout several periods of very high water. At one time the river stood at elevation 24 at the pump station for a period of about twenty-four hours.

This station furnished during the year a total of 680,000,000 gallons of water.

The station was closed down on May 28, 1910, on which date the new pumping station at the Agua Clara reservoir was put into service. The dismantling of the station is now in progress, and portions of the steam plant and all quarters in connection with the station have been removed.

CONDENSER PLANT.

Effort has been made to furnish all employees with condensed water for drinking and cooking purposes; a total of 4,200,000 gallons of this water was supplied.

NEW WATER SUPPLY, GATUN.

The construction of the Agua Clara reservoir (see Pl. 101), with the exception of the filter plant, was completed along the general lines noted in the annual report for 1909. The cost of this work was increased and the progress retarded very much by the unusually heavy rainfall during the latter part of 1909 and January of this year.

Working conditions were very unfavorable for a period of more than six months for this class of work, but the necessity for the early completion of the water supply demanded that every effort be made to finish it.

The concrete cut-off wall was carried across the old creek bed and into good solid clay. The total length of this wall is about 100 feet. The elevation at the bottom of the wall near the center of the creek is -5.

The gate chamber was founded on piles driven to solid rock. After the lower valves and fittings had been set, and the concrete finished to a point about 15 feet above the stream, the valves in the waste pipe were closed. By this time the fill had been built up to a point sufficiently high to permit the water to rise in the basin. The earth fill was then carried up in layers a foot thick.

A concrete footbridge was constructed to the gate chamber.

Two 3-stage turbine pumps, switchboard, and transformers were received and installed in the pump station.

The pump station was constructed throughout of reinforced concrete.

The spillway has a clear waterway of 80 feet, and is built of concrete with an earth dyke at each end.

The following table shows the amount of work done on the various items:

Total fill in dam, earth and rock	cubic yards	105,000
Top soil from dam site	do	1,200
Excavation in cut-off wall	do	315
Concrete in cut-off wall	do	370
Concrete in waste pipe, etc	do	230
Piles in foundation of gate chamber	do	36

Concrete in gate chamber	cubic yards..	210
Concrete in bridge	do....	42
Concrete in pumping station	do....	190
Concrete in spillway	do....	1,000
Excavation for spillway	do....	2,550
Length of 12-inch pipe line	linear feet..	6,814
Length of 36-inch waste pipe	do....	252
Spillway fill	cubic yards..	2,000
Fill in dike	do....	800

The elevation of the water in the reservoir on June 30 was +60, 8 feet below the crest of the spillway.

GATUN SEWERS.

All new commission houses at Gatun were connected with the sewer system. The usual maintenance of the system was continued, a number of breaks repaired, and some minor changes made.

In June, 1910, a portion of the 10-inch outfall sewer was relocated. The stream into which the sewer was discharging became blocked, owing to dredging operations, and it was necessary to relocate the sewer. It now discharges into the main sanitary ditch at the north end of the locks, and from there flows in the open drainage ditch to the west diversion. A total of 2,000 feet of 10 and 12 inch pipe was used in this work.

SANITARY DITCHES.

The work of constructing and maintaining sanitary ditches was continued throughout the year. A new ditch 500 feet long was constructed, and an average of 8,200 feet of ditch was regraded, cleaned, and widened each month.

NEW GATUN WATER SUPPLY.

During the year the extension of the water service authorized for 1909 was completed. About two-thirds of the water service for the town is now completed.

NEW GATUN SEWER SYSTEM.

The sewer system at New Gatun was completed, and during the year considerable progress was made in the installation of plumbing in the buildings.

GENERAL CONSTRUCTION.

A large amount of water pipe was laid during the year, in connection with the various construction plants at Gatun. New lines were laid to the dam, and the old ones removed, as the progress of construction of the dam necessitated. A new line was laid to Mindi, and an additional line laid to the old pump station. A number of standpipes were erected for the use of locomotives. Various minor jobs were completed.

The following table shows the number of feet of various sized pipe laid:

	Feet.
1¼-inch	8,690
1½-inch	2,240
2-inch	12,530
2½-inch	550
3-inch	13,421
4-inch	17,450
5-inch	2,680
6-inch	7,807
8-inch	2,525
12-inch	6,814
16-inch	632
	75,349

ROADS.

Mount Hope-Gatun Road.—This road was completed early in the year. A total of 1,886 cubic yards of crushed rock was used, and 270 cubic yards of sand and gravel were used as binder. The road was fenced on both sides from Mount Hope to Mindi, a total length of 5.25 miles, 4-strand barbed-wire fence being used.

A road to the commissary and the Panama Railroad station was completed; also a new road from house No. 17, Gatun, to the corral. Several short pieces of road were built, and the usual repairs and maintenance of all roads and walks kept up.

The following table shows the amount of new road work completed at Gatun during the year:

Road.	Length.	Width.	Thickness.	Square yards.
	Feet.	*Feet.*	*Inches.*	
Commissary approach, Panama R. R.	700	20	10	1,555
Road to corral	1,400	20	8	3,111
Road from house No. 3 to new contract houses	300	16	6	523
Road (relocated)	150	16	6	267
Road for fire protection	600	10	10	800
Panama R. R. station	150	10	10	167
Total				6,435

Excavation and fill.

Road.	Fill.	Excavation.
	Sq. yds.	*Sq. yds.*
Commissary approach, Panama R. R.	848	
Road to corral		1,836
Road from house No. 3 to new contract houses		200
Road for fire protection	100	
Panama R. R. station	200	
Total	1,148	2,036

COLON WATER SUPPLY.

No alterations or changes of importance were made in this system during the year. The filtration plant was in continuous operation.

The accompanying table (Exhibit 2) shows the rainfall at Brazos Brook, the elevation of the Brazos Brook reservoir, and the operation of the filter plant and pump station for the year.

BRAZOS BROOK RESERVOIR.

The condition of the water in the reservoir at Brazos Brook was excellent throughout the year.

A small gang of laborers was employed during the year clearing the slopes of the reservoir. A total of about 1,500,000 square yards were cleared.

Owing to the settlement of the dam and dikes, authority was given to raise them to elevation 55. A total of 1,715 cubic yards of earth was used in this work.

Repairs were made to the concrete apron under the 48-inch waste pipe, for which 10 cubic yards of concrete were used.

ROADS.

The road from Cristobal to Mount Hope was resurfaced. A road from Mount Hope to the dry dock and a road from Cristobal to dock 13 were constructed.

The following table shows the number of square yards of material used:

Road.	Crushed rock.	Sand binder.	Ditches.	Earth fill.	Macadam.
	Cu. yds.	*Cu. yds.*	*Lin. ft.*	*Cu. yds.*	*Sq. yds.*
Cristobal to Mount Hope	1,806	100			12,768
Mount Hope to dry dock	200		1,070		927
Cristobal to dock 13	64			205	330
South end of quartermaster's office	95				570

FIRE PROTECTION.

A total of 2,000 feet of $2\frac{1}{2}$-inch, 4-inch, and 6-inch pipe was laid at the cold-storage plant, dock 11, dock 13, and connected with the fire hydrants for the protection of these structures.

SEA WALL, CRISTOBAL.

A total of 173 concrete blocks were made and placed in the sea wall at Cristobal Point, completing this work.

CRISTOBAL SEWERS.

Various small extensions were made to this system, 1,125 feet of pipe being used. All new houses were connected with the sewers, as constructed, and the usual maintenance and up-keep of the system continued.

FOLKS RIVER.

A total of 1,695 feet of 8-inch and 10-inch pipe was laid at Folks River to accommodate the new houses constructed in this district.

COLON IMPROVEMENTS.

The surveys and plans for the improvements in Colon were completed.

Authority was given in January for the construction of the D street storm sewer, at an estimated cost of $125,000. On account of the increased cost of material and changes in plans, this estimate was later increased to $136,000.

The sewer will run from the sea at Beach Road on the north to Folks River on the south, with outlets at each end. The summit elevation will be at Eighth street. There will be three cross sections; the minimum section running from Sixth to Eleventh streets; the intermediate section, from Eleventh to Fourteenth streets and from Sixth to Third streets, and the maximum section from Third street to the sea and from Fourteenth street to Folks River. These several sections are semicircular in their lower half and rectangular in their upper half. The flow in this sewer will be actuated by a head of 1.8 feet.

Work was started in January. A standard guage track was laid parallel to the ditch, connecting with the Panama Railroad main line at Folks River and the First street track in Colon, a distance of little over a mile. Excavation was started in March, by hand, at a point where the sewer runs under a large house on Beach Road. A locomotive crane was received and put into service in April, but fully two-thirds of the excavation to date has been made by hand. It is now intended to do most of the excavation by hand, or until work is started in the large section at Folks River. The large amount of ground and surface water getting into the trench has caused some delay, but on the whole satisfactory progress has been made.

A set of collapsible steel forms was constructed at the Gorgona shops and have proved very satisfactory. These forms were used for the entire cross sectional area, except about two and one-half of the invert, which is placed ahead of the forms, using the rodding method to give it proper shape.

The following table shows the amount of work completed to date:

Excavation	cubic yards..	6,473.6
Back fill	do....	1,081.0
Invert laid	linear feet..	1,515.9
Concrete in invert	cubic yards..	603.2
Sewer crown built	linear feet..	1,440.0
Concrete in crown	cubic yards..	1,025.4
Total concrete	do....	1,628.6
Reinforcement ($\frac{5}{8}$-inch iron)	linear feet..	38,538.0
Reinforcement (steel rails)	do....	21,774.0

A general plan of raising the street grades by hydraulic fill for that part of Colon inclosed by Second and Ninth streets, between D and G streets, and by Ninth and Fourteenth streets, between D and E streets, is now being prepared.

This general plan contemplates also the installation of sewers and water, construction of macadam streets, paving of the alleys in the large blocks, and the installation of larger pumps and pipe line at the sump to take care of additional sewage.

So far the only work done in connection with the general plan has been the laying of sewer and water lines through Hudson lane.

Authority has been given for the improvements of the surface-drainage system at Bottle alley, from Second to Fifth streets.

At these points it is intended to lay 20-inch and 24-inch pipe to replace the present 16-inch pipe. Cement pipe is now being made for this work.

The following table shows the amount of pipe laid and work done in the Hudson lane water and sewer line:

Sewer.

Excavation	cubic yards..	2,034.3
Backfill	do....	1,865.0
10-inch vitrified pipe laid	linear feet..	720.0
8-inch vitrified pipe laid	do....	1,010.0
6-inch vitrified pipe laid	do....	790.0
Laterals laid		79
Manholes		4
Concrete in manholes	cubic yards..	31.0
4-inch drain tile laid	linear feet..	1,730.0

Water.

8-inch water line laid	linear feet..	1,190.0
8-inch valves set		2
House connections		28

TORO POINT WATER SUPPLY.

This work involves the construction of a small dam at the source of supply, at elevation 190. From this point the water will be conveyed 2 miles by 8 and 6 inch pipe to the reservoir. This reservoir will have a capacity of 48,000,000 gallons, with an elevation at the top of 120. The reservoir will be formed by three small dams located in a saddle of the hills. From this point the water will be conveyed through a 6-inch pipe to Toro Point, a distance of 1½ miles.

Work was started May 23 on the construction of a cart road for the transportation of pipe. This road is 3½ miles long and was completed in June. Several thousand feet of pipe were shipped to Sweetwater Harbor and Toro Point and unloaded. To date 2,300 feet of the 8-inch main has been laid from the dam. A small amount of preliminary work was done at the reservoir in opening borrow pits and clearing the reservoir basin.

MISCELLANEOUS.

LOCAL MACHINE SHOP.

Minor repairs to the locomotives, steam shovels, and other machinery used in connection with the work at Gatun have been made at the local machine shop throughout the year.

General overhauling and extensive repairs of steam shovels have been made, as heretofore, at the Empire shops.

Repairs to standard-gauge locomotives in service in the vicinity of Gatun, when the estimated cost was more than $50 and less than $500, were made at the Panama Railroad shops at Cristobal, and when more than $500 at the Gorgona shops.

DIVISION OFFICE.

The usual clerical duties were performed in connection with miscellaneous correspondence, reports, cost accounting, pay rolls, and other routine papers.

DIVISION DRAFTING ROOM.

The following is a summary of the work done in the drafting room during the fiscal year:

Preparation of drawings to accompany the annual report of the division engineer, 1908–9.

Analysis of the stresses in the lock cableway towers and drawings of modifications of the back legs.

Design and detailed drawings of the auxiliary mixing plant.

Details of trestles of the tail towers of the lock cableways at the south end of the locks, and for both head and tail towers at the north end of the locks.

Design and detailed drawings of the Agua Clara waterworks and filter plant.

Designs and detailed drawings of various collapsible steel forms for construction work in the locks and in Colon.

Designs and drawings for various minor repairs and modifications of the material handling and concrete mixing and placing plants.

Design and drawings for 300-foot steel bridge across the spillway.

Final design and drawings of the D street sewer.

Design and drawings for modifications of the sewerage pumping station at Colon.

Detailed drawings of spare parts of practically all the machinery in the main handling plant.

Design and drawings of the Gatun coal chute.

Design and drawings of the auxiliary rock bin.

Design and drawings of the auxiliary sand bin.

Design and drawings of the east and west retaining walls at the south end of the locks.

Design and drawings of the north approach wall, Gatun locks.

Design and drawing of the concrete pile footings for the shipping bins at Porto Bello.

Studies for modifications in sand and rock barges.

Design and drawings of the east and west approach walls of the spillway lying without the hydraulic fill.

Design and drawings for auxiliary pumping station.

Detailed drawings of construction monoliths for the locks.

Designs and drawings for concrete vault, division office.

Designs and drawings of 24 derricks for lock-wall forms.

Designs and drawings for the transverse retaining wall at the south end of the forebay of the locks.

Design and drawings of a Howe truss footbridge across the locks.

Design and drawings for framed bent trestle over the main stock pile at Gatun.

Design and drawings of modifications of the present circulating water intake for the power house.

Design and details of 12-ton derrick car.

Drawings for miscellaneous small parts of machinery.

During the year approximately 7,500 blueprints were made.

Respectfully submitted.

WM. L. SIBERT,
Division Engineer, Atlantic Division.

Col. GEO. W. GOETHALS, U. S. Army,
Chairman and Chief Engineer, Culebra, Canal Zone.

EXHIBIT 1.

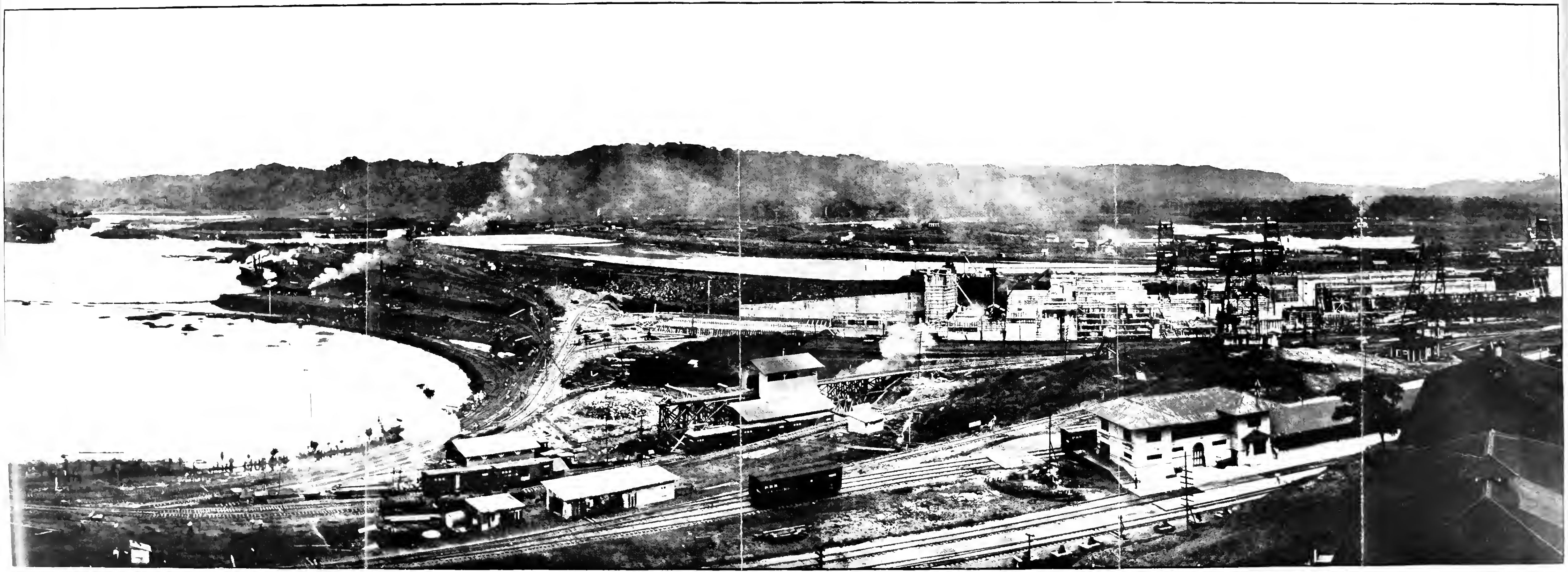
Progress report for fiscal year 1909–10.

	Locks.	Dam and spillway.	Mindi and break-water.	Dredg-ing.	Porto Bello.	Nom-bre de Dios.	Munici-pal en-gineer.	Total.
Steam shovel excavation:								
In prism...cubic yards.	873,145	11,260	324,716	....	....	....	....	1,209,121
Auxiliary.........do....	9,845	135,834	1,118	....	409,589	36,388	....	592,774
Dredge excavation:								
In prism..........do....	....	....	....	4,955,840	....	....	....	4,955,840
Auxiliary.........do....	....	279,049	68,170	618,768	....	114,376	....	1,080,363
Total excavation......	882,990	426,143	394,004	5,574,608	409,589	150,764	....	7,838,098
Explosives used, tons 2,240 pounds..................	56.99	81.82	37.12	157.41	342.91	....	6.06	682.31
Power drilling.........feet..	113,038	4,050	20,715	54,665	168,883	....	....	361,351
Hand drilling.........do....	214,453	101,709	22,549	....	2,112	....	2,200	423,023
New track laid........do....	62,097	112,981	10,977	....	26,416	10,477	8,151	231,099
Material placed in dams, yards....................	....	5,520,460	....	....	....	....	90,211	5,610,671
Cement:								
Received.......barrels..	553,772	66,322	....	....	....	....	4,735	626,519
Used.............do....	525,919	58,549	....	....	....	....	2,781	587,249
On hand..........do....	27,853	7,773	....	....	....	....	1,954	38,270
Stone:								
Received........yards..	494,991	34,890	....	....	....	....	5,168	535,049
Used.............do....	452,264	30,415	....	....	397	....	1,966	485,042
On hand..........do....	42,727	617	....	....	....	....	30	43,374
Sand:								
Dredged..........do....	....	....	....	....	....	84,883	....	84,883
Received.........do....	264,209	27,873	....	....	404	....	2,064	294,540
Used.............do....	229,804	27,460	....	....	404	....	2,050	259,708
On hand..........do....	34,405	413	....	....	....	....	14	34,832
Rock crushed, June...do....	....	....	....	....	490,556	....	....	490,556
Crushed rock used....do....	....	....	....	....	....	....	....	....
Concrete placed ......do....	513,802	49,551	....	....	1,130	....	19,474	581,365
Lumber:								
Received ....feet b. m..	....	....	....	....	....	....	....	....
Used.............do....	....	....	....	....	....	....	....	....
On hand..........do....	....	....	....	....	....	....	....	....
Forms erected:								
Steel...........pounds..	16,705,328	....	....	....	....	....	....	16,705,328
Wooden .....feet b. m..	6,832,912	....	....	....	....	....	....	6,832,912
Steel work placed..pounds..	1,606,035	....	....	....	....	....	....	1,606,035
New roads built........feet..	....	....	....	....	300	....	14,239	14,539
Water mains laid.....do....	....	....	....	....	....	....	33,374	33,374
Sewers laid...........do....	....	....	....	....	282	....	13,426	13,708
Open drains and ditches dug..................feet..	....	....	....	....	2,095	200	10,340	12,635
Average daily force employed	2,507	1,339	240	1,256	686	153	524	6,705

EXHIBIT 2.

Colon water supply—Mount Hope pump station and filter plant.

Month.	Rainfall.	Brazos Brook reservoir elevation.	Alkalinity.		Coagulant (alum sulphate).	Turbidity.		Color.		Odor.		Bacteria.		Wash water.	Monthly consumption.
			Raw.	Filtered.		Raw.	Filtered.	Raw.	Filtered.	Raw.	Filtered.	Raw.	Filtered.		
1909.	*Inches.*				*Pounds.*									*Gallons.*	*Gallons.*
July	12.83	42.5	21.0	5	23,925	50	0	50	5	Vegetable and earthy	0	268	2,250	2,500,000	64,700,000
August	10.61	44.0	22.0	6	21,450	50	0	60	10	do	0	300	12,000	2,100,000	67,100,000
September	10.02	43.0	20.5	5	23,642	50	0	20	10	Fishy and earthy	0	560	18,000	3,267,740	63,518,000
October	14.97	44.0	20.0	2	22,275	40	0	100	10	do	0	900	1,600	3,432,000	67,127,000
November	38.17	47.0	21.0	2	28,000	30	0	80	0	do	0	1,200	1,000	2,954,000	61,648,000
December	37.14	49.4	16.0	1	28,100	40	0	40	0	do	0	1,250	530	2,203,000	64,036,000
1910.															
January	4.03	48.9	16.0	3	24,000	30	0	30	5	do	0	340	330	2,103,000	59,503,000
February	3.34	46.1	16.0	18	22,000	60	0	20	5	do	0			2,210,520	53,098,000
March	10.37	44.4	17.0	6	16,884	20	0	32	0	do	0	525	180	2,100,000	55,748,000
April	6.45	42.9	19.0	7	13,282	30	0	35	0	do	0	269	160	2,280,000	55,809,000
May	11.24	42.3	24.0	5	15,099	40	0	40	0	do	0	288	185	2,500,000	58,329,000
June	10.72	45.0	25.0	6	15,900	50	0	42	0	Vegetable and earthy	0	300	85	2,106,000	51,339,000
Total	169.89				254,353									29,752,260	729,955,000



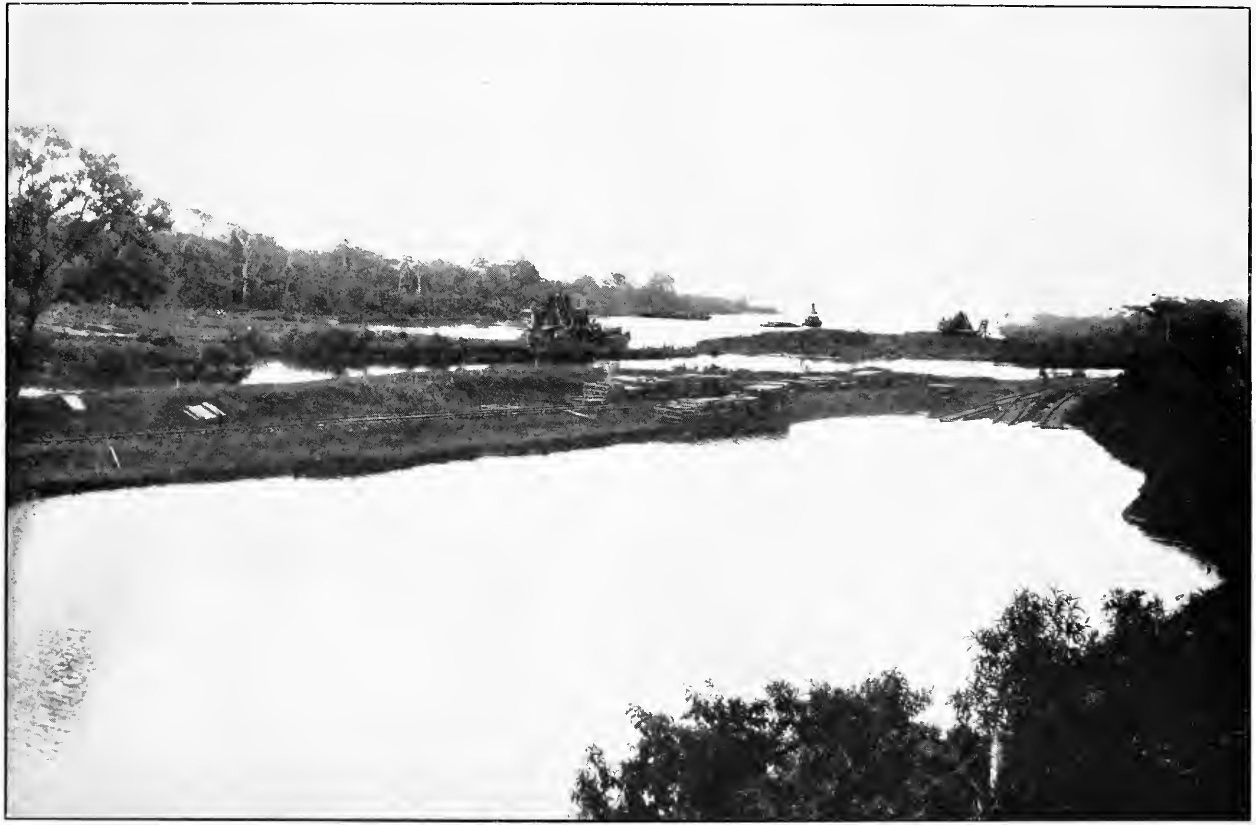
SITES OF GATUN DAM AND LOCKS FROM THE EAST, JUNE, 1910.

TORO POINT, SHOWING CAMP AND SHELTER COVE, JULY, 1910.

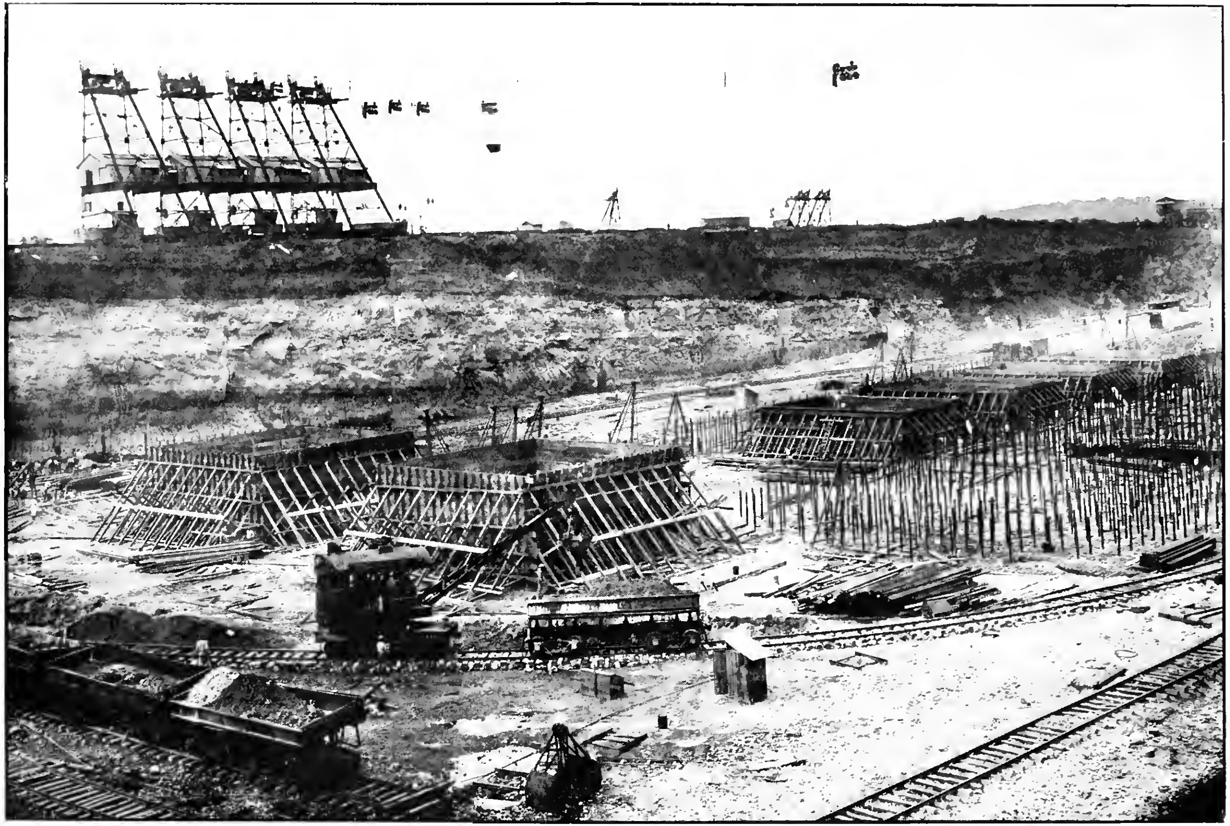
ATLANTIC DIVISION, HARBOR AND CHANNEL SECTION, MAY 23, 1910. LOOKING SOUTH ALONG CANAL NEAR MINDI; WIDTH OF CHANNEL ABOUT ONE-HALF THAT OF COMPLETED CANAL.

ATLANTIC DIVISION, HARBOR AND CHANNEL SECTION, MAY 23, 1910. FRENCH LADDER DREDGE WORKING IN THE CANAL CHANNEL NEAR MINDI.

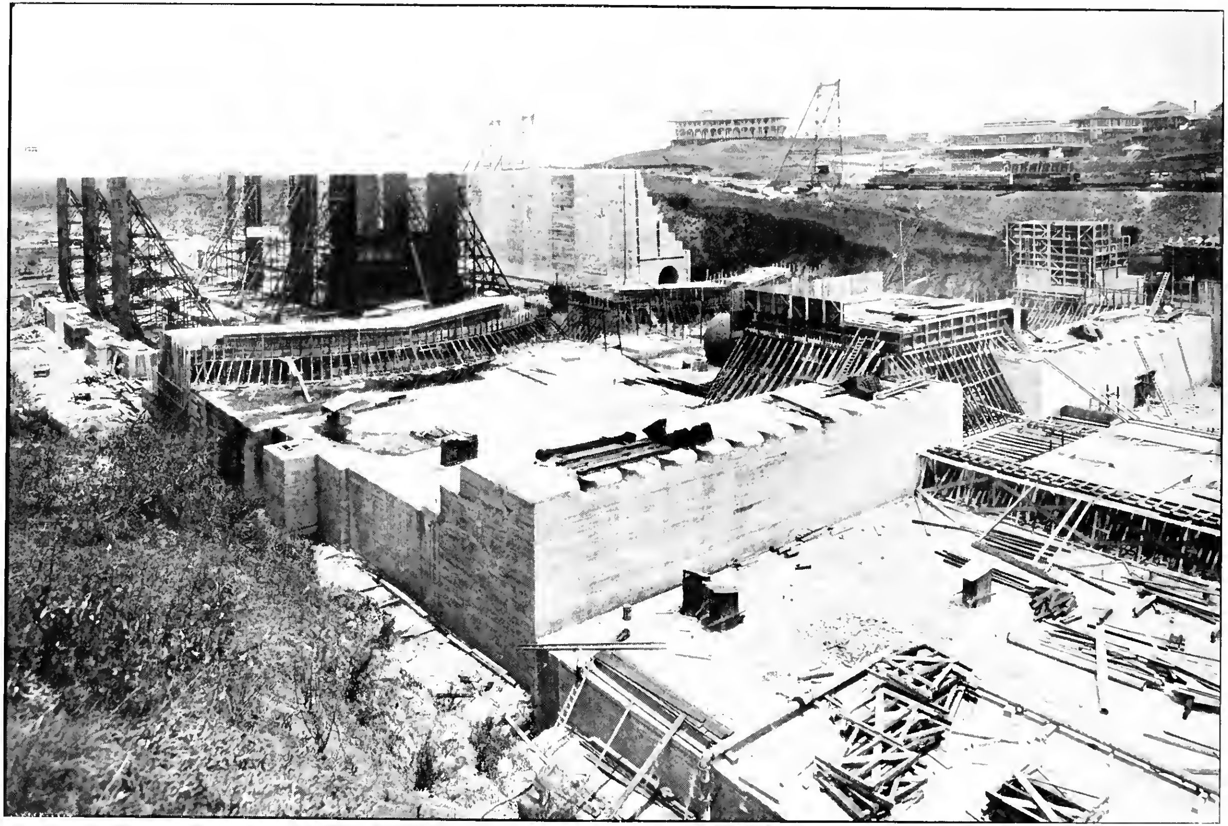
Plate 7.



ATLANTIC DIVISION, HARBOR AND CHANNEL SECTION, JULY, 1910. LOOKING NORTH ALONG AXIS OF CANAL AT MINDI; DREDGE ABOUT TO CUT THROUGH INTO FRENCH CANAL.



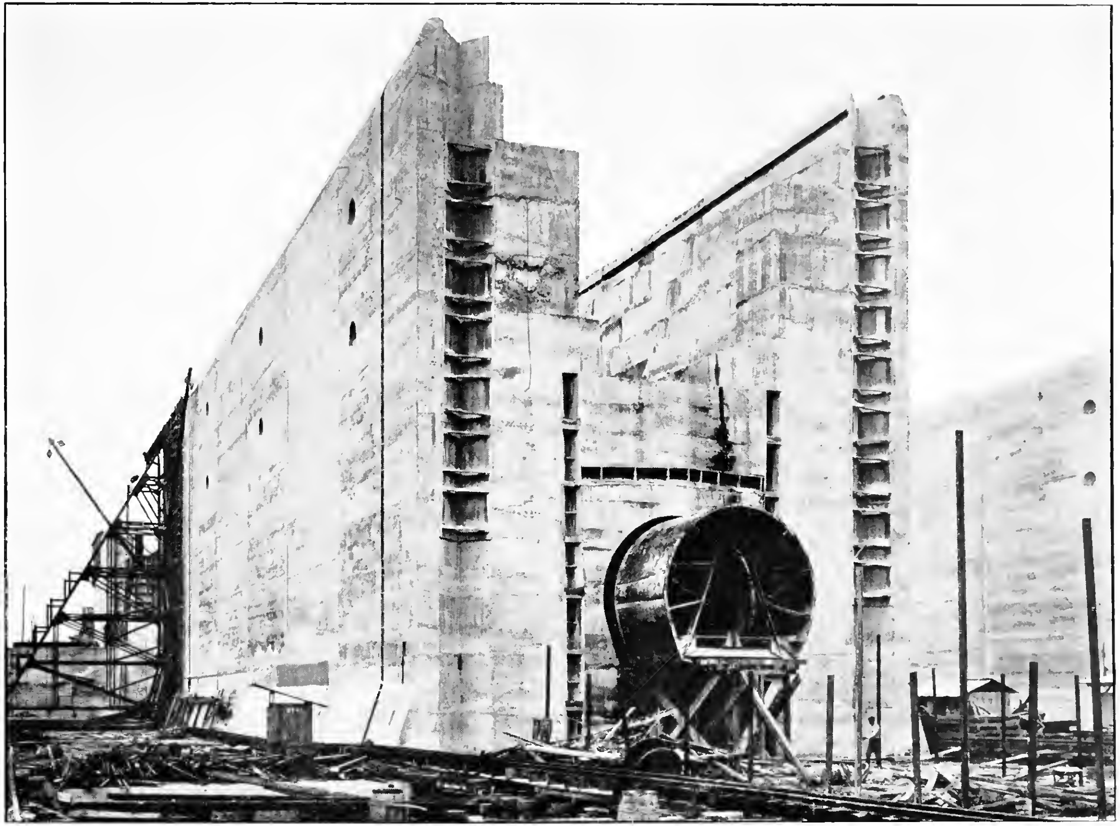
GATUN LOCK SITE, LOOKING NORTH FROM EAST BANK, AUGUST 25, 1909.



Gatun Locks, looking north from West Wall, March 15, 1910.

GATUN LOCKS, JULY 19, 1910. LOOKING SOUTH, SHOWING WALLS OF UPPER LOCKS AND FLOOR UNDER CONSTRUCTION IN MIDDLE LOCKS.

GATUN LOCKS, JULY, 1910. GENERAL VIEW OF UPPER LOCKS AND FOREBAY, LOOKING NORTH.



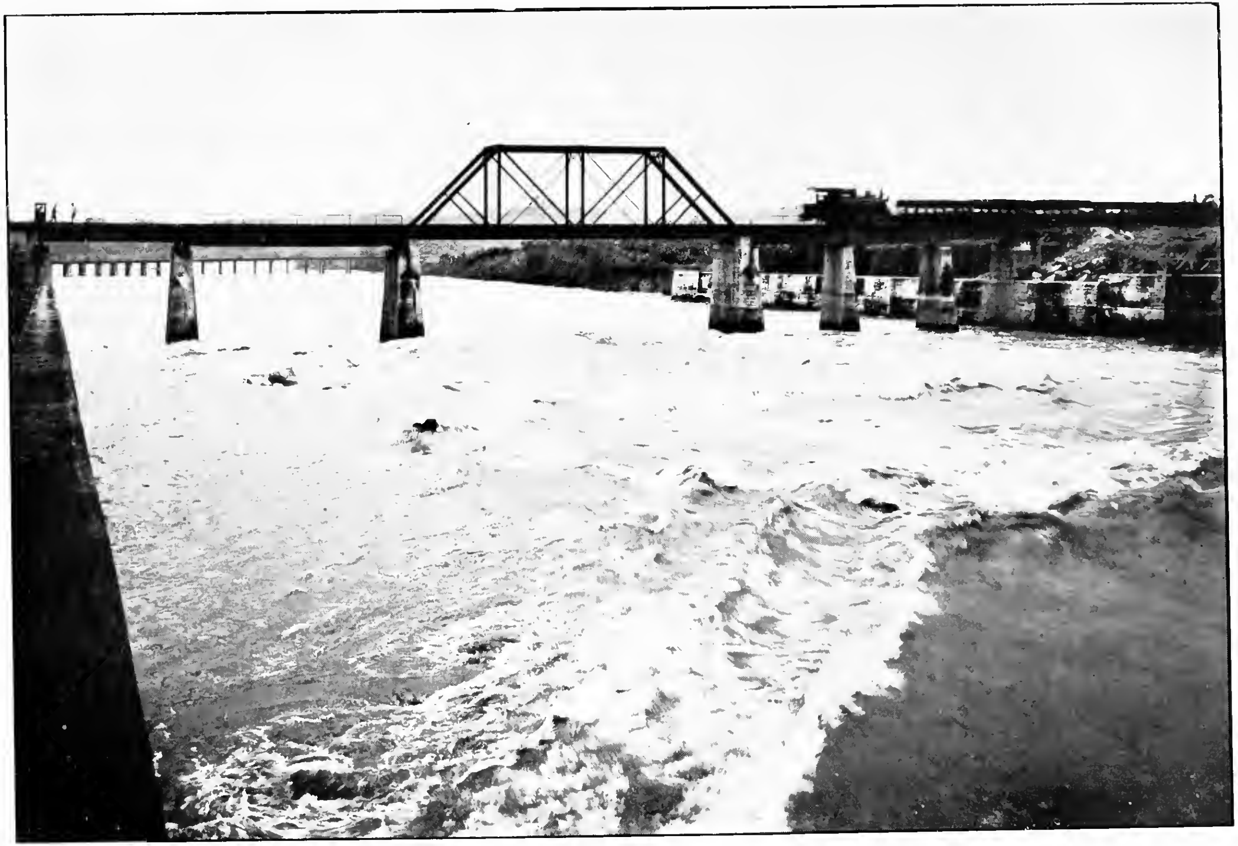
GATUN LOCKS, JULY, 1910. MONOLITHS IN MIDDLE WALL.

GATUN DAM, SOUTH TOE, WEST OF SPILLWAY, JULY, 1910. DRY FILL AT ELEVATION +35 TO +50; HYDRAULIC FILL AT ELEVATION +16.

PLATE 14.

GATUN DAM, HYDRAULIC FILL EAST OF SPILLWAY, JULY, 1910. DISCHARGE FROM DREDGE AND RELAY PUMP, LIFT, 63 FEET; LENGTH OF PIPE, 4,300 FEET.

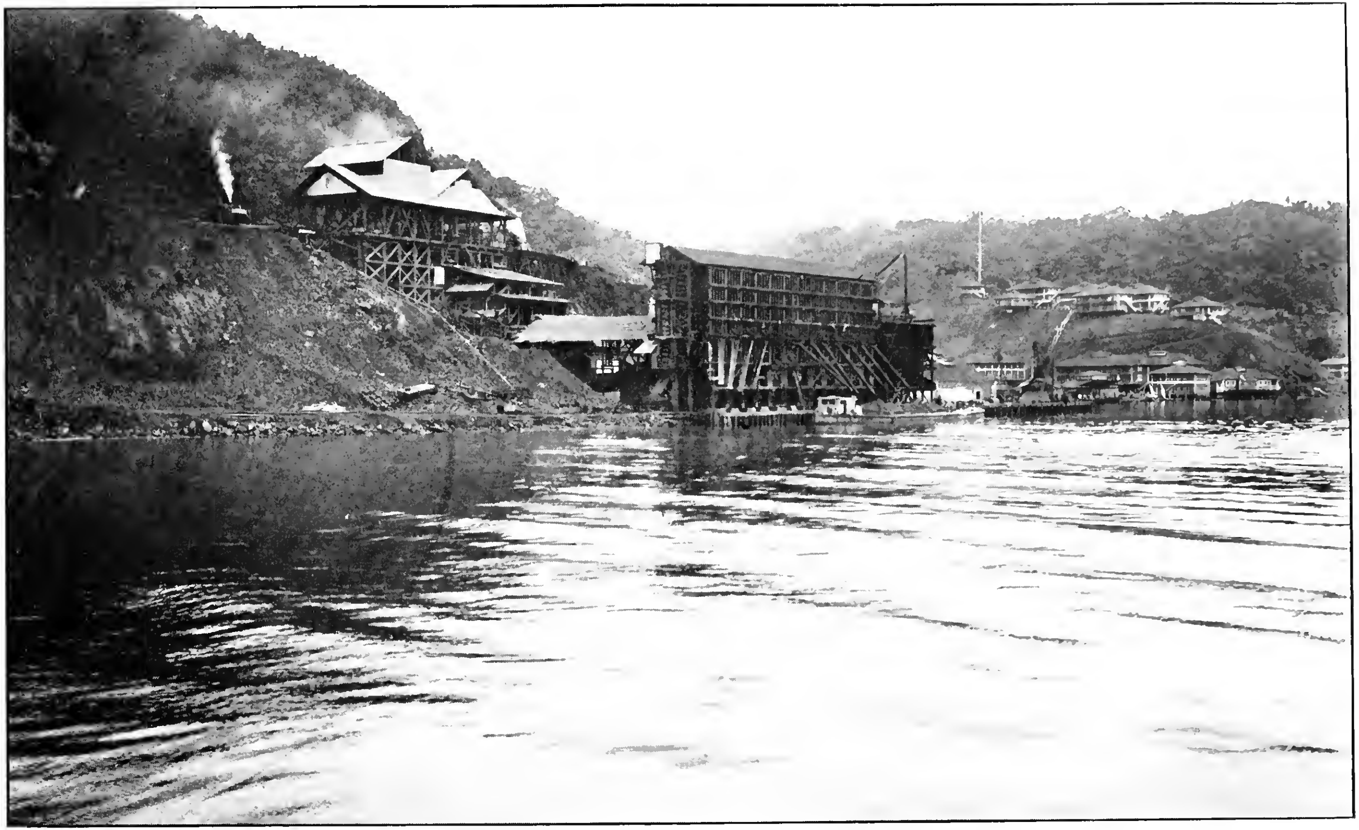
GATUN SPILLWAY, LOOKING NORTH FROM WEST WALL. FOUNDATIONS FOR VALVE AND COFFERDAM PIERS IN FOREGROUND. APRIL 24, 1910.



GATUN SPILLWAY, LOOKING NORTH, JULY, 1910. OUTFLOW FROM GATUN LAKE AT ELEVATION +16.

Plate 17.

AGUA CLARA RESERVOIR, GATUN, JULY, 1910. DAM NEARLY COMPLETED.



PORTO BELLO QUARRY, JULY 30, 1910. VIEW FROM HARBOR, SHOWING CRUSHING PLANT AND SHIPPING BINS.

CONSTRUCTING A STORM SEWER IN "D" STREET, COLON, JULY, 1910.

Plate 20.

METHOD OF EXCAVATION FOR STORM SEWER, "D" STREET, COLON, JULY, 1910.

APPENDIX D.

REPORT OF LIEUT. COL. D. D. GAILLARD, CORPS OF ENGINEERS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, DIVISON ENGINEER, CENTRAL DIVISION.

ISTHMIAN CANAL COMMISSION,
OFFICE OF DIVISION ENGINEER, CENTRAL DIVISION,
Empire, Canal Zone, July 26, 1910.

SIR: I have the honor to submit the following report of operations in the central division for the fiscal year ending June 30, 1910:

This division extends from the south toe of Gatun dam to the north end of the lock site at Pedro Miguel, a total distance along the axis of the canal of 31.69 miles, and embraces the entire extent of the former Culebra and Chagres divisions, which are now known as the Culebra and Chagres sections of the central division.

The total amount of material excavated in the above territory during the fiscal years ended June 30, 1904–1910, is given in the following table:

FROM CANAL PRISM.

Fiscal year ending June 30—	Earth.	Soft rock.	Hard rock.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1904	24,024	30,070	6,013	60,107
1905	397,043	246,998	97,603	741,644
1906	764,327	489,054	253,181	1,506,562
1907	2,288,199	2,449,546	832,687	5,570,432
1908	5,078,864	6,508,055	1,872,459	13,459,378
1909	6,151,152	9,100,852	3,190,620	18,442,624
1910	4,570,728	10,578,603	2,656,780	17,806,111
Total	19,274,337	29,403,178	8,909,343	57,586,858

FROM OBISPO DIVERSION.

Fiscal year ending June 30—	Earth.	Rock.	Unclassified.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1907	128,001	45,221		173,222
1908	240,063	73,448		313,511
1909	293,745	329,535		623,280
1910	26,066			26,066
Total	687,875	448,204		1,136,079

OUTSIDE WORK.

1907	2,680		21,680	24,360
1908	64,233	2,140		66,373
1909		1,873		1,873
1910	33,631			33,631
Total	100,544	4,013	21,680	126,237

TOTAL EXCAVATION, INCLUDING ACCESSORY WORK.

Fiscal year ending June 30—	Earth.	Rock.	Unclassified.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1904	24,024	36,083		60,107
1905	397,043	344,601		741,644
1906	764,327	742,235		1,506,562
1907	2,418,880	3,327,454	21,680	5,768,014
1908	5,383,160	8,456,102		13,839,262
1909	6,444,897	12,622,880		19,067,777
1910	4,630,425	13,235,383		17,865.808
Total	20,062,756	38,764,738	21,680	58,849,174

The amount of material removed during each month since the United States assumed control in May, 1904, is shown graphically on Plate 102.

The following table shows the amount (place measurement) of material excavated monthly in the central division during the fiscal year ended June 30, 1910:

Month.	From canal prism.			Total, including accessory works.		
	Earth.	Rock.	Total.	Earth.	Rock.	Total.
1909.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
July	363,677	1,065,393	1,429,070	369,332	1,065,393	1,434,725
August	357,530	1,043,355	1,400,885	361,558	1,043,355	1,404,913
September	363,352	1,107,649	1,471,001	364,147	1,107,649	1,471,796
October	328,013	1,196,297	1,524,310	328,013	1,196,297	1,524,310
November	196,165	968,246	1,164,411	196,165	968,246	1,164,411
December	251,978	1,005,088	1,257,066	253,445	1,005,088	1,258,533
1910.						
January	366,919	1,132,576	1,499,495	366,919	1,132,576	1,499,495
February	412,346	1,133,136	1,545,482	412,346	1,133,136	1,545,482
March	705,048	1,282,666	1,987,714	711,908	1,282,666	1,994,574
April	545,294	1,166,552	1,711,846	556,787	1,166,552	1,723,339
May	387,630	960,623	1,348,253	391,691	960,623	1,352,314
June	292,776	1,173,802	1,466,578	318,114	1,173,806	1,491,916
Total	4,570,728	13,235,383	17,806,111	4,630,425	13,235,383	17,865,808

In determining costs, the following yardage was used:

	Cubic yards.
From canal prism	17,806,111
From Obispo diversion	26,066
Total	17,832,177

In addition to the above yardage, 33,631 cubic yards of miscellaneous outside material were excavated, for which no credit was given, making a grand total for the fiscal year of 17,865,808 cubic yards, as shown above.

The maximum monthly amount of material, including accessory work excavated in the division during the fiscal year, aggregated 1,994,574 cubic yards removed in March, 1910. The maximum monthly amount of material excavated in the division since the inception of the work was 2,054,088 cubic yards removed in March, 1909. As stated in the last annual report, the output of March, 1909, will probably be the highest reached during the construction of the canal on account of the decrease of available working space as the depth increases.

Of the total amount of material excavated during the fiscal year, 17,558,364 cubic yards were removed by steam shovels and loco-

motive cranes equipped with clam shell or orange peel buckets, 116,440 cubic yards by hand and 157,373 cubic yards by contractors. In addition to this, 33,631 cubic yards of plant excavation was accomplished, but not included in the canal excavation.

The material excavated by shovels is carried by dirt trains to dumps situated from 1 to 24 miles from the place of loading, the average haul being about 12 miles.

REVISED ESTIMATE OF THE QUANTITY OF MATERIAL YET TO BE REMOVED.

A revised estimate of the quantity of material to be excavated in the central division after June 30, 1910, in order to complete the canal, was submitted to the chairman and chief engineer and approved. This estimate gives an increase of 7,330,525 cubic yards over the old estimate, which was made in September, 1908.

Details of the new estimate are given in the following table:

Location.	Districts.				
	Chagres.	Empire.	Culebra.	Pedro Miguel.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
Inside prism lines	2,493,979	11,353,879	15,075,923	1,456,641	30,380,422
Slides		387,150	4,980,000	100,000	5,467,150
Silting in Chagres River	670,000				670,000
Outside 10 on 1 slope		451,648	460,755	93,535	1,005,938
Additional excavation to +39	251,965				251,965
Addition for drainage of cut		159,200	318,800	56,000	534,000
Total	3,415,944	12,351,877	20,835,478	1,706,176	38,309,475

The increase is due to—

1. The widening of the basin north of Pedro Miguel locks added 932,572 cubic yards.
2. Excavation to elevation 39 feet above sea level, which has been deemed advisable in the Chagres section, increased the estimate by 251,965 cubic yards.
3. Experience with high water in the Chagres River during the rainy season of 1909, when 152,515 cubic yards of sand and gravel were deposited in the canal at Santa Cruz and Matachin, makes it advisable to allow 670,000 cubic yards for silting.
4. During the fiscal year a number of new slides have developed and the banks of the canal have broken in several places where such action was not anticipated when the estimate of September, 1908, was made.

Although the estimated yardage remaining has been materially increased by the allowance for breaks, slides, and silting, yet it is believed that neither the ultimate time of completion of work in the central division nor the ultimate cost as estimated in October, 1908, will be increased, as since that estimate was submitted the cost of excavation in the central division has decreased materially and the rate of progress has been greater than was then anticipated.

Up to and including June 30, 1910, 58,815,543 cubic yards, or 60.55 per cent of the total estimated excavation, had been removed, leaving 38,309,475 cubic yards, or 39.44 per cent, yet to be removed

to complete all excavation within the limits of the central division. This excavation is divided as follows:

	Culebra section.		Chagres section.	
	Cubic yards.	Per cent.	Cubic yards.	Per cent.
Removed	49,317,870	58.56	9,497,673	73.55
Yet to be removed	34,893,531	41.44	3,415,944	26.45

BLASTING.

The total amount of material mined during the fiscal year was 12,158,996 cubic yards, which was 463,884 cubic yards less than in the previous year.

During the year, 153 well or mechanical churn drills and 235 tripod drills were in operation, all of which were run by compressed air.

The number of linear feet of holes drilled during the year was as follows:

Kind of drilling.	Linear feet.	Miles.
Tripod drills	2,019,176	382.42
Well drills	2,063,067	390.73
Hand drills	272,461	51.60
Total	4,354,704	824.75

The quantity of explosives used during the year amounted to a total of 3,157.3 gross tons, which was 207.7 gross tons less than the amount used during the previous fiscal year.

Of this amount, 2,337,420 pounds were saltpeter dynamite of 60 per cent nitroglycerine; 4,756,400 pounds saltpeter dynamite of 45 per cent nitroglycerine, and 16,376 pounds "Palmerite," a patented nitrostarch powder. In using this dynamite, the following blasting materials were used:

Detonators		174,585
Tape fuse	feet	906,765
Electric fuses:		
2-foot		2,830
3-foot		1,495
10-foot		90
16-foot		4,325
20-foot		75,673
24-foot		115,960
30-foot		132,220
35-foot		85,930
40-foot		79,305
50-foot		15,330
60-foot		150
Tape, insulated	rolls	5,055
Wire:		
Connecting	spools	1,702
Lead	feet	304,198

Very stringent rules have been published covering the handling, storage, and use of explosives. The distribution of explosives to the different parts of the work is under the direct charge of a super-

visor and the explosives are always handled by the same engine and train crew. An inspector is in charge of the loading of the drilled holes and another inspector is in charge of the wiring, as all shots are fired by a "live wire" and the shooting done by experienced blasting wire men.

Owing to the above precautions and the great care taken in the handling of explosives, personal injuries have been nearly eliminated from this part of the work. During the fiscal year just passed, although over 7,100,000 pounds of dynamite were used, but one man was killed while handling dynamite, and his death was caused by the fact that he miscalculated the length of time required for the fuses to burn and returned to an unfired "dobe" shot too soon. Five men were injured on account of premature explosions and two others on account of miscalculation of the time required for the fuses to burn and too early return to unfired "dobe" shots.

STEAM SHOVELS.

The total number of steam shovels assigned to the central division during the year was 61. These shovels were of the following sizes:

Class of shovel.	Number in service.	Capacity of dipper.
		Cu. yds.
45-ton Bucyrus	2	1¾
70-ton Bucyrus	13	3
Do	1	2½
95-ton Bucyrus	26	5
Do	6	4
Model 60, Marion	2	2½
Model 91, Marion	11	5

The number of cubic yards excavated by shovels per hour while under steam averaged 155.8 cubic yards for the present fiscal year as compared with 150.46 cubic yards for the previous year and 121.4 for the fiscal year 1907–8.

The highest daily, monthly, and annual records for shovels of each class are given in the table below:

	High daily record.			High monthly record.				High annual record.		
	Date.	Yardage.	Shovel number.	Date.	Yardage.	Shovel number.	Days worked.	Yardage.	Shovel number.	Days worked.
45-ton Bucyrus	Feb. 5, 1908	1,356	58	July, 1908	25,713	59	26	105,740	54	131
70-ton Bucyrus	May 7, 1909	2,630	128	Mar., 1909	53,043	122	27	300,872	122	254
95-ton Bucyrus	Mar. 22, 1910	4,465	213	Mar., 1910	70,290	213	26	453,062	208	263
Model 60, Marion	Apr. 18, 1908	1,704	152	Mar., 1908	41,219	152	26	....	....	......
Model 91, Marion	Jan. 21, 1909	3,485	265	Aug., 1908	55,419	256	25	369,714	265	292

The following table shows the average performance of steam shovels for each month of the fiscal years ended June 30, 1908, 1909, and 1910:

Month.	Working days.	Output per shovel.				Rainfall at—		
		Per day.	Per month.	Per hour—		Bas Obispo.	Empire.	Culebra.
				Under steam.	At work.			
1907.		Cu. yds.	Cu. yds.	Cu. yds.	Cu. yds.	Inches.	Inches.	Inches.
July	26	683.1	17,670	89.5	167.8	8.25	9.89	9.31
August	27	719.5	19,428	93.6	164.6	12.69	11.24	11.81
September	24	818.2	19,636	105.9	184.7	14.71	10.86	11.38
October	27	791.9	21,385	100.5	176.8	13.62	15.44	15.27
November	24	773.3	18,562	89.9	170.6	9.85	10.40	6.91
December	25	922.3	23,057	120.7	192.2	2.26	1.47	2.30
1908.								
January	26	1,039.5	27,031	131.2	208.4	.20	.75	.91
February	24	1,112.1	26,690	142.2	215.6	.11	.00	.01
March	26	1,159.4	30,146	147.2	221.6	.41	.41	.13
April	25	1,191.1	29,780	152.9	230.6	1.81	1.36	1.67
May	25	905.7	22,618	115.2	201.4	13.18	12.91	12.43
June	26	1,011.2	26,294	130.6	210.5	6.55	8.21	8.86
Average	305	931.9	23,685	121.4	199.1	83.64	82.94	80.99
1908.								
July	26	1,073.2	27,902	137.9	206.9	9.14	11.79	13.23
August	26	1,119.6	29,300	144.7	216.2	10.23	8.11	7.58
September	25	1,180.2	29,585	140.8	202.9	5.76	9.75	15.18
October	27	1,185.3	32,228	148.3	214.1	9.42	8.85	8.91
November	23	1,154.8	26,693	145.8	222.5	6.95	4.46	5.26
December	26	1,210.5	31,474	151.8	232.4	6.63	5.09	4.40
1909.								
January	25	1,183.0	29,575	148.3	225.8	2.59	2.28	2.96
February	23	1,260.4	29,342	157.7	246.8	4.72	1.50	2.46
March	27	1,327.2	35,835	167.5	258.5	.45	.21	.15
April	25	1,283.7	32,120	160.9	242.5	5.90	3.33	2.56
May	25	1,182.9	29,507	148.5	229.3	12.98	7.72	7.36
June	26	1,242.9	32,315	156.3	240.5	11.71	7.84	9.44
Average	304	1,198.9	30,371	150.4	227.6	86.48	70.94	79.49
1909.								
July	26	1,206.9	31,379	152.1	238.8	11.59	8.27	7.95
August	26	1,132.8	29,668	142.0	218.9	7.03	7.20	8.32
September	25	1,248.3	31,208	156.3	239.8	7.90	7.22	8.40
October	26	1,230.1	32,679	154.1	237.0	16.98	21.13	17.70
November	24	1,161.3	27,875	147.8	223.9	28.41	21.08	24.46
December	26	1,114.6	28,982	141.9	224.9	12.33	9.44	10.58
1910.								
January	25	1,252.3	31,307	159.5	238.5	1.24	.70	1.31
February	23	1,272.8	29,274	161.6	224.1	1.80	.76	.93
March	26	1,388.0	36,090	176.8	260.2	3.12	1.60	1.36
April	26	1,295.2	33,674	163.8	291.5	3.85	4.24	5.35
May	25	1,263.8	31,596	172.3	276.8	11.09	11.08	10.50
June	26	1,229.2	31,962	156.2	238.2	12.08	10.17	11.16
Average	304	1,231.0	31,185	155.8	236.1	117.42	102.89	108.02

The number of cubic yards per hour under steam for the fiscal year ended June 30, 1908, averaged from 89.5 cubic yards to 152.9 cubic yards, and during the year ended June 30, 1909, from 137.9 cubic yards to 167.5 cubic yards, while during the fiscal year ended June 30, 1910, the average ranged from 142 cubic yards to 176.8 cubic yards, a marked increase in the average efficiency of the operation of steam shovels during the three years in question. In comparing the average daily and monthly yardages shown in the tables above

it should be borne in mind that these averages are based on a day of eight hours, while the working day in most other places where steam shovels are operated is ten or more hours in length.

The average output per shovel per day within the limits of the central division for each month since the commencement of operations by the United States is shown graphically on Plate 103.

PLANT.

The motive power, rolling stock, and construction equipment of the central division in service on June 30, 1910, was as follows:

Cars:	
Decauville (industrial)	363
Dump—	
King-Lawson	1
Steel "Western"	419
Steel, Oliver	298
Steel, Goodwin	12
Wooden, Ingoldsby	12
Flat—	
Steel	44
Lidgerwood	1,671
Motor	3
Pay	1
Locomotive cranes:	
15-ton	2
25-ton	4
100-ton	1
Locomotives:	
Decauville, 040 class	2
19 by 24, 260 class	111
15 by 22, 060 class	2
12 by 18, 042 class	1
17 by 24, 440 class	1
16½ by 23½, 060 class	25
20 by 26, 260 class	19
Pile drivers:	
Moonbeam	3
Swing circle	1
Plows, unloading:	
Right	18
Left	18
Steam shovels:	
45-ton Bucyrus	2
70-ton Bucyrus	14
95-ton Bucyrus	32
Model 60 Marion	2
Model 91 Marion	11
Spreaders:	
Jordan	2
Mann-McCann	12
Track shifters	6
Unloaders:	
25-ton Lidgerwood	3
60-ton Lidgerwood	25

TRANSPORTATION.

The average number of locomotives working per day and the total locomotive days during the year were as follows:

Class of work.	Average per day.	Total number of days.
Handling spreaders	7.18	2,192
Handling unloaders	10.97	3,346
Handling track shifters	4.35	1,329
Handling dirt and miscellaneous trains	125.50	38,266
Average per day and total	148.00	45,133

The average number of cars loaded daily with excavated material and the total number hauled during the year was as follows:

Class of cars.	Average per day.	Total number handled.
Lidgerwood flats	2,156.16	657,646
Large steel dumps	193.10	58,827
Small steel dumps	1,179.08	359,671
Average per day and total	3,528.34	1,076,144

The largest number of cars handled in one day during the year was on March 22, 1910, when the following number were handled:

Lidgerwood flats	2,648
Large steel dumps	179
Small steel dumps	1,946
Total	4,773

TRACKS.

The amount of trackage in the central division was increased by 5.93 miles during the year, making a total trackage in this division on June 30, 1910, of 200.25 miles. This statement, however, gives a very vague idea of the amount of track laid and taken up during the year in order to provide running tracks and loading tracks for the steam shovels in the cut. To do this, approximately 213 miles of track were removed, 219 miles of track laid, about 10 miles of track renewed, and 1,534.6 miles of track shifted. In addition, 556 frogs and switches were removed and 927 switches and frogs laid during the fiscal year.

At the close of the fiscal year there were 62.03 miles of track in the Culebra cut alone, or an average of seven tracks throughout the entire length of 8.5 miles of the cut. The location and distribution of the track in the central division is given in the following table:

Name and location.	1907.	1908.	1909.	1910.
	Feet.	*Feet.*	*Feet.*	*Feet.*
In canal prism	190,205	272,321	364,163	385,884
Tabernilla to Chagrecito	23,724	27,835	27,835	6,529
Powder-house line, Santa Cruz			10,526	9,860
High line (Obispo diversion track)		26,421	25,860	29,472
Bas Obispo	3,910	4,560	6,833	13,914
Old Gamboa and Las Cascadas	24,142	3,376	2,890	
Cucaracha	10,610	6,400	4,145	
Paraiso	16,158	22,430	14,140	22,150
Old Panama R. R	19,803			
Pedro Miguel	31,207	61,944	60,244	46,980
Miraflores third track	2,700	3,005	3,005	3,005
Corozal yard and third track	5,500	5,500		
East Mamei				2,750
Total east of canal	137,754	161,471	155,478	134,660
Gorgona				1,800
Caimito		2,065	3,135	
Juan Grande	3,176	5,313		10,201
Alligator curve	8,691	9,011	9,011	6,700
Gorgona yard	29,327	31,958	37,172	37,172
Matachin		1,240	4,160	9,219
Bas Obispo	10,778	10,066	10,460	4,670
Las Cascadas and bridge 52	15,905	21,775	13,310	22,300
Whitehouse	20,423	21,780	16,130	18,400
High line, Whitehouse to Lirio		11,940	7,075	7,273
Cunette	6,004	4,495	3,220	3,118
Empire	13,444	39,431	46,213	44,518
Lirio	10,696	23,530	26,694	26,100
Culebra	11,136	15,554	8,415	11,083
Rio Grande	15,623	16,504	17,123	16,855
Cucaracha	23,480	17,278	8,060	5,850
Paraiso				5,346
Total west of canal	168,683	231,940	210,178	229,805
Tabernilla prism dumps				3,225
Tabernilla	36,819	62,640	80,195	82,895
San Pablo		5,120	9,475	1,120
Caimito		9,053	10,540	985
Mamei	2,140	3,421	3.481	5,300
New Panama R. R. north of Juan Grande			2,094	8,028
Point No. 3			2,915	13,500
Gorgona		10,429	9,500	10,560
New Panama R. R. south of Juan Grande			16,347	45,866
Matachin:				
East of canal			3,154	
West of canal	2,832	3,332	10,259	1,068
Santa Cruz:				
East of canal		2,720	10,978	2,850
West of canal		5,224	5,224	
Lirio	29,840	8,625	10,115	3,725
Gold Hill		20,094	18,895	11,730
Cardenas River (Miraflores)	3,336	37,200	37,989	39,343
Soza-Corozal Dam	5,100	14,520		
Balboa (La Boca "Y") and dumps	10,782	49,151	65,035	76,800
Total on dumps	90,849	231,531	296,196	306,995
Total track used by central division, exclusive of Panama R. R. main line	587.491	897,263	1,026,017	1,057,344
Total track ... miles	111.27	169.94	194.32	200.25

NOTE.—Of the 169.94 miles shown in 1908, 151.57 miles were on the old Culebra division and 18.37 miles were on the old Chagres division.

DUMPS.

During the year 17,749,306 cubic yards of material were deposited in the various dumps named in the accompanying table:

Name of dump.	Wasted prior to July 1, 1909.	Wasted during fiscal year 1909–10.	Total wasted.	Remaining capacity.
Gatun	401,184	1,157,494	1,558,678	4,000,000
Bohio	100,544	77,384	177,928	
Chagrecito		98,463	98,463	
Tabernilla	10,184,800	4,895,949	15.080,749	8,104,051
San Pablo	1,815,420	113,845	1,929,265	
Caimito	1,289,031	191,671	1,480,702	
Panama R. R. relocation, Caimito to Gamboa	1,226,233	3,281,986	4,508,219	3,000,000
Mamei	552,805	228,055	780 860	1,000,000
Juan Grande	860,296	26,425	886,721	
Gorgona	683,408	45,949	729,357	333,801
Santa Cruz	880,998	116,584	997,582	
Gamboa	184,629	3,163	187,792	
Bas Obispo dike		5,174	5,174	
Bas Obispo crusher	144,391	39,843	184,234	
Haut Obispo	29,039	6,486	35,525	
Obispo diversion	1,062,582	8,313	1,070,895	
Gold Hill	874,833	10,700	885,533	
Panama R. R. relocation, Paraiso to Corozal	538,837	286,704	825,541	3,000,000
Miraflores	3,846,657	3,116,478	6,963,135	8,000,000
Balboa	5,562,124	3,652,852	9,214,976	28,347,148
Naos Island trestle		182,239	182,239	
Miscellaneous	2,919,535	203,549	3,123,084	
Dumped prior to July 1, 1909, on dumps not used this year	7,908,891		7,908,891	
Total	41,066,237	17,749,306	58,815,543	55,785,000

The number of dumps has necessarily decreased as the depth of the canal has increased, as it is impossible to haul loaded trains out of the canal except at either end of the Culebra cut. Trains are run from the south end of the cut at Pedro Miguel to dumps at Balboa and Miraflores; and from the north end of the cut to the Gatun dam, the dumps at Tabernilla or over the Gamboa Bridge to dumps on the Panama Railroad relocation. Several new dumps of limited capacity have been opened up in the Chagres section to take care of local excavation.

The average amount of material dumped per day at the larger dumps was as follows:

	Cubic yards.
Tabernilla	16,052
Miraflores	10,218
Balboa	11,977
Gamboa to Caimito (relocation)	10,761

The material deposited at Balboa is serving a very useful purpose in reclaiming from the ocean land which in time will be very valuable.

Prior to June 30, 1909, 145 acres of land in this locality had been filled in and during the fiscal year ended June 30, 1910, 108 acres have been reclaimed, making a total of 253 acres. The material deposited at Tabernilla and Miraflores is wasted.

The material dumped on the Panama Railroad relocation is used for filling the trestles and for raising the embankment to the desired level. Two million three hundred and fifty-one thousand three hundred and thirty-four cubic yards of material from the central division were dumped for this purpose during the fiscal year ended June 30, 1910, making a total of 3,666,118 cubic yards in all furnished to that date by the central division. In addition to this amount 854,099

cubic yards were deposited on small dumps developed to the east of the relocated line.

In compliance with instructions of March 20, 1908, from the chairman and chief engineer, the central division continued to furnish hard rock for use in constructing the toes of the Gatun dam. The material excavated at Buena Vista was also transported to Gatun. The total amount of material delivered at Gatun during the fiscal year was 1,157,494 cubic yards, making a total of 1,558,678 cubic yards in all. The daily average number of trains from Culebra cut to Gatun was 10.6, and the highest number hauled in one day was 23 on June 24, 1910.

The following table shows the amount of trestle driven in the central division in connection with dumping operations during the fiscal years 1908, 1909, and 1910:

Name and location.	1908.	1909.	1910.
Balboa (La Boca) dumps	13,350	6,539	4,074
Sosa Dam dumps	8,270		
Cardenas River dumps (Miraflores)	8,595	1,742	
New Panama R. R., Pedro Miguel	1,518		
New crossing Panama R. R., over canal	364		
Lirio coal trestle and bridges	1,367		
White House yard, north end	56		
Canal connection, bridge No. 53	182		
Haut Obispo to Bas Obispo		395	
Tunnel trestle, Bas Obispo	312		
Bas Obispo		1,256	
Near bridge No. 52		178	
Canal connection, Matachin	448	780	
Santa Cruz		1,330	
Powder house line, Santa Cruz		1,361	
Matachin to Santa Cruz		136	
Point No. 3		439	
Gorgona dumps	2,405	15	
Relocation dumps			4,045
Caimito to Tabernilla		505	110
San Pablo to Rio Cano			
Tabernilla dumps	9,113	897	
Trestles in cut	392		169
Obispo diversion	5,330	1,923	456
Miscellaneous	1,099	1,131	
Redriven and repaired	400	882	2,260
Total ... feet	53,401	19,509	11,114
Total ... miles	10.11	3.09	2.10

During the fiscal year work was in progress at a number of different places in the central division, and the names of the localities and the amount of work accomplished at each place during the fiscal year, together with the amount yet to be done, is given in what follows:

DIVERSIONS.

The diversions or intercepting canals, protecting the Culebra cut from water which would otherwise flow into it from the adjacent watershed, are three in number, those on the Atlantic slope being known as the Obispo and Camacho diversions, located on the east and west sides of the cut, respectively. That on the Pacific watershed, located on the west side of the cut, is known as the Rio Grande diversion. No diversion has been constructed on the Pacific watershed to the east of the cut, for the reason that the Cucaracha slide prevents the maintenance of any intercepting or diversion canal in that vicinity.

With but a single interruption of about three days, in the case of the Obispo diversion, these diversions have rendered excellent service throughout the fiscal year, and if there had ever been any doubt as to the necessity for their construction in order that excavation might proceed during rainy weather, such doubt would have been dispelled during the unusually wet season of the past fiscal year.

On May 7 at La Pita Point on the east side of the canal about half a mile north of Empire a section of the rock bank of the canal, amounting to about 40,000 cubic yards, broke away and slipped into the cut. The Obispo diversion at this point was excavated in rock and was only about 60 feet from the edge of the canal, and was enabled by this break in the bank to discharge its water into the canal. Steps were at once taken to construct a channel and a flume around the broken section of the bank, which was about 175 feet in length. The water was effectually diverted from the canal on May 10 and a temporary wooden flume completed before the close of the fiscal year. During the next dry season it is intended to replace this temporary flume by a permanent construction of reenforced concrete or rubble masonry, as may be found most expedient when the broken section of the bank has all been removed.

Gaugings were made at various times throughout the year to determine the maximum discharge of the three diversions and of the cut itself at the north and south ends. The maximum discharge of the Obispo diversion at La Pita Point, on the east side of the canal about one-half a mile north of Empire, on October 6, 1909, was 1,980 cubic feet per second; that of the Camacho diversion at the tunnel just north of Bas Obispo, on November 29, 1909, was 3,755 cubic feet per second. The maximum flow in the Rio Grande diversion on November 17, 1909, was 816 cubic feet per second. The Rio Grande reservoir is located at the head of the latter diversion and helps materially in modifying the maximum discharge. The maximum discharge in the bottom of the cut at the south end occurred on October 6, 1909, amounting to 600 cubic feet per second, and the maximum discharge in the bottom of the cut at the north end occurred on November 19, 1909, amounting to 110 cubic feet per second. With a cut 8½ miles in length and varying in depth from 40 to 400 feet below the natural surface of the ground, it can readily be seen from the discharges just quoted that it would be practically impossible to prosecute work successfully during the wet season without the diversions already described.

CULEBRA SECTION.

This section extends from Gamboa to Pedro Miguel and is usually known as the "Culebra cut." The time of completion of excavation within the limits of the central division will be fixed by the time necessary to complete the Culebra section; consequently all efforts are concentrated on this particular part of the work. Previous to June 30, 1909, 34,371,443 cubic yards had been excavated in the Culebra section. During the fiscal year ending June 30, 1910, 14,921,750 cubic yards were excavated, leaving 34,893,531 cubic yards yet to be excavated in order to complete this section of the canal.

The work of so widening the canal that the entire Culebra section should have a bottom width when completed of not less than 300

feet necessitated disturbing several miles of banks on this part of the canal which had for the most part attained a stable condition. As a consequence, a number of new slides have developed, and in addition in places along the deeper parts of the cut where the rock is unusually soft, and especially where there are numerous faults and seams, portions of the bank have broken away and settled down into the canal, thus necessitating the removal of a considerable amount of material lying wholly outside the slope lines of the canal. The slides and breaks just mentioned are discussed more in detail under the heading "Slides and breaks."

The material removed from slides and breaks outside of the slope line during the fiscal year ending June 30, 1909, amounted to 884,530 cubic yards, while in the fiscal year ending June 30, 1910, it amounted to 2,649,563 cubic yards, nearly all of which in both cases was removed from the Culebra section. The quantity in the former year amounted to about 7 per cent of all material removed from this section during that year and in the latter to about 18 per cent. Included in the revised estimate for the completion of all work in the central division is an allowance of 6,400,000 cubic yards for future slides and breaks outside of the slopes and berms within the limits of the Culebra section.

Below Gamboa the Chagres River is a winding stream and crosses the axis of the canal twenty-three times before it reaches Gatun, forming a series of peninsulas which, commencing at Gamboa, are known as "Point 1," "Point 2," "Point 3," etc.

POINT 1.

Work on Point 1 was commenced February 24, 1908, and was carried on continually until June 15, 1909, when owing to the fact that great annoyance was caused by heavy rains and high water in the Chagres River, it was deemed best to discontinue work during the rainy season and to complete the same during the following dry season. Accordingly, work was commenced January 20, 1910, and completed May 28, 1910. In all 1,246,761 cubic yards have been taken out at Point 1, of which 286,560 cubic yards were taken out during the past fiscal year.

Unusually high floods in the Chagres River in October and November caused the deposit of 43,198 cubic yards of gravel and silt in this section of the canal, most of which was removed during the fiscal year. Future gravel deposits will be removed and the gravel used for track ballast and concrete. Silt deposits will be removed by means of suction dredges when Lake Gatun has been flooded.

POINT 2.

Point 2 lies between Matachin and Gorgona, the cut through this point being 2,700 feet long, 500 feet bottom width, and 50 feet in average depth. Excavation in this locality was begun December 30, 1907, and completed May 25, 1909. The waters of the Chagres River were turned into the completed cut on June 9, 1909.

The bottom of the cut as completed was only 2 or 3 feet above the bottom of the Chagres River at the point where the latter entered the cut, and the heavy floods of the past fiscal year brought in

deposits of gravel amounting to about 109,317 cubic yards, 56,238 cubic yards of which were removed by steam shovel and orange peel crane and used as ballast for construction tracks, thereby effecting a considerable saving as compared with the cost of crushed stone previously used for this purpose.

No other work than the removal of this gravel was done at Point 2 during the past fiscal year. During the next dry season the removal of gravel for use in concrete and as ballast will be continued. Any deposits of gravel or silt left in the cut at Point 2 will be removed by suction dredge when Lake Gatun has been flooded to a suitable level.

POINT 3.

The area to be excavated at Point 3 lies on the east side of the Chagres River opposite Gorgona. Excavation at Point 3 was begun on June 12, 1909, and continued to the close of the fiscal year, at which time, although only 157,522 cubic yards remained to be excavated, yet it was found necessary to remove the tracks and shovels for the reason that very slight rises in the Chagres River, which would inevitably occur at frequent intervals during the next six months would flood the cut and prevent further steam-shovel work until the following dry season.

In all 832,646 cubic yards were removed from Point 3 from the commencement of work on June 12, 1909, to the close of the fiscal year ended June 30, 1910. The small amount of material remaining which consists wholly of clay and silt will be loosened by blasting, with the expectation that the greater part of it will be carried away by floods in the Chagres River. All material remaining within the prism at the time the waters of Lake Gatun reach this point will be removed by suction dredges.

POINT 4.

Point 4 lies on the left bank of the Chagres River at Gorgona. Excavation was begun at this point June 2, 1910, and by the close of the fiscal year 10,646 cubic yards were removed. The total amount of material to be removed at this point after June 30, 1910, aggregates 841,221 cubic yards. It is intended to excavate all that portion of the prism at Point 4 lying above elevation +50 feet by means of steam shovels during the wet months of the fiscal year ending June 30, 1911, and to excavate in the same manner as much as possible of the remainder to an elevation of +40 feet during the dry season of the same fiscal year. Any material remaining thereafter will be removed by suction dredge as in the cases previously described.

JUAN GRANDE (POINT 5).

Excavation by steam shovel was commenced at Juan Grande on June 2, 1910, and by the close of the fiscal year 23,824 cubic yards had been removed. The estimated amount of material remaining to be removed at this locality on July 1, 1910, was 472,489 cubic yards. Two shovels are engaged in the work at this point.

POINT 6.

Excavation by steam shovel was commenced at Point 6 on May 2, 1910, and by the close of the fiscal year 46,741 cubic yards had been removed. The estimated amount of material remaining to be removed at this locality on July 1, 1910, was 142,320 cubic yards. One shovel is engaged on the work at this point.

EAST MAMEI.

Hand work at East Mamei was commenced April 15, 1910, and excavation by steam shovel on June 15, 1910. By the close of the fiscal year 8,315 cubic yards had been removed. The estimated amount of material remaining to be removed at this locality on July 1, 1910, was 635,230 cubic yards. Two shovels are engaged in the work at this point.

MAMEI.

Work was commenced at Mamei on September 17, 1909, and up to the close of the fiscal year, 372,671 cubic yards had been removed, leaving 49,356 cubic yards yet to be removed. Steam-shovel work at this locality will be completed by the close of the month of July, 1910.

CAIMITO.

Excavation at Caimito was begun October 1, 1907, and by the close of the fiscal year ended June 30, 1909, 1,929,897 cubic yards of material had been removed. During the fiscal year ending June 30, 1910, 338,675 cubic yards were removed from this locality and the work was completed April 22, 1910.

SAN PABLO.

Work at San Pablo was commenced on October 1, 1907, and by the close of the fiscal year ended June 30, 1909, 1,219,909 cubic yards had been removed. During the fiscal year ending June 30, 1910, 5,899 cubic yards were removed, leaving 257,959 cubic yards to be removed in order to complete work in this locality. This material forms the roadbed for the double tracks of the Panama Railroad and can not be removed until this section of the railroad is abandoned, which will probably not occur for a year or two yet.

CANO RIVER.

Cano River lies on the west bank of the Chagres River, nearly opposite Tabernilla. Work was commenced at this locality on December 15, 1908, and completed September 24, 1909. The total amount of material removed aggregated 707,031 cubic yards.

TABERNILLA.

Work was commenced at Tabernilla on November 13, 1909, and ceased on June 17, 1910, owing to the fact that the remaining material could not be excavated until the double tracks of the Panama Rail-

road and the machine shop were removed. The total amount of material removed previous to the beginning of the fiscal year was 14,051 cubic yards. During the fiscal year 392,490 cubic yards were removed. The total amount remaining in order to complete all work at this point is 86,729 cubic yards. This material will probably be removed at the same time as that at San Pablo.

BUENA VISTA.

Near the native village of Buena Vista on the right bank of the Chagres River are two hills, parts of the sides of which had to be removed in order to give the necessary channel width and depth. Work was commenced at this locality with steam shovels on June 29, 1909, and completed on November 10, 1909, during which period a total of 153,026 cubic yards of material were removed.

BOHIO.

The only work done by steam shovels at Bohio consisted in removing a rock hill near the north end of the village. This work was commenced on September 4, 1909, and completed on November 10, 1909, a total of 33,874 cubic yards having been removed during this period.

HAND WORK BY THE UNITED STATES.

Owing to the fact that there were a number of isolated elevations which projected but a short distance above the proposed level of the bed of the canal, it was believed that it would be most economical to remove them by hand labor, the work to be done either by employees hired by the United States or by contractors. In both cases the laborers were furnished by the Isthmian Canal Commission with portable narrow-gauge track and old French push cars of the Decauville type. Work by laborers hired by the United States was commenced in January, 1909, and was completed November 10, 1909. The total amount of material thus removed aggregated 184,148 cubic yards in Bohio and vicinity.

HAND WORK BY CONTRACT.

A contract was entered into with Messrs. Hebard & Alberts on November 22, 1909, to excavate about 160,947 cubic yards from the canal prism between San Pablo and Bohio at a cost of 35 cents per cubic yard. Work was begun by the contractors on December 1, 1909, and by the close of the fiscal year 156,976 cubic yards had been excavated by them, leaving 14,223 cubic yards still to be excavated.

Another contract was entered into with Mr. Earl McFarland on March 21, 1910, to excavate about 202,410 cubic yards from the canal prism between Tabernilla and Bohio, at a cost of 21 cents per cubic yard for earth, 25 cents per cubic yard for soft rock, and 30 cents per cubic yard for hard rock. No actual excavation has been done by the contractor up to the close of the fiscal year.

A third contract was entered into with Mr. B. B. Duncan on February 15, 1910, to excavate 397 cubic yards on miles 14 and 15 and miles 19 and 20, at a cost of 40 cents per cubic yard. This was finished March 15, 1910.

CUTTING TIMBER AND BRUSH FROM THE CHANNEL IN LAKE GATUN.

The work of clearing, grubbing, and burning trees in the channel in Lake Gatun was commenced at the beginning of the dry season and the following work done during the fiscal year:

BY EMPLOYEES OF CENTRAL DIVISION.

Trees cut on 61.6 acres at a cost of $645.57, or $10.48 per acre.

BY CONTRACT WITH B. B. DUNCAN.

Trees cut, piled, and burned on 855.8 acres at a cost of $30,164.91, or $35.24 per acre.

In addition to the above, Messrs. Hebard & Alberts cleared 33 acres in connection with their contract for excavation.

There still remain 162 acres to be cleared within the next year to complete the entire width of channel throughout the central division.

NAOS ISLAND DIKE.

In order to construct the dike from East Balboa to Naos Island a pile trestle was driven from the shore toward the island, which is situated in Panama Bay a little over 3 miles from the mainland. From this trestle material from the Culebra cut is dumped, and when the trestle is completely filled tracks are thrown and the dike widened and used as a dump.

Previous to June 30, 1909, the trestle had been constructed for a distance of a little over 2 miles. During the fiscal year ending June 30, 1910, this trestle was extended 1,123 feet, giving a total length of trestle from the shore line of 2.4 miles. The end of the trestle on June 30, 1910, was 4,900 feet from Naos Island, and the filling extended to within 400 feet of the end of the trestle.

Much trouble has been experienced during the past year in extending the outer end of the dike, owing to the sliding of the bottom, due to the weight of the stone filling dumped from the trestle. This sliding has been encountered at every foot of the last 4,000 feet of the dike, and results in continual settlement of the roadbed for the first two or three months, when it gradually diminishes and finally ceases. In several places on the dike the sum of the daily vertical settlements of the roadbed amounted to over 60 feet in three months, the behavior of the bottom material being very similar to that encountered in filling the trestles along the toes of the Sosa-Corozal dam in 1907.

Formerly the tidal currents crossed the channel in Panama Bay from east to west, depositing in it a large amount of sediment. The work so far accomplished in the construction of this dike has been of material benefit, not only in decreasing the deposit of sediment, but also in protecting vessels from the currents which at times rendered it somewhat difficult for them to navigate the channel. When this dike has been completed the entire artificial channel in its vicinity will be protected from currents and abnormal deposits of silt.

SLIDES AND BREAKS.

Previous to the commencement of the present fiscal year the movement of material into the canal from outside of the prism was due almost entirely to slides caused by the movement of the top layer of

clay upon the smooth sloping surface of rock or other material much harder than the clay itself. The overlying top layer of clay in such cases varied in thickness from about 10 to 40 feet, the average thickness being from 15 to 20 feet.

The widening of the canal in the Culebra section necessitated the cutting of fresh slopes through this top covering of clay for a distance, including both sides of the canal, of about 6 miles; consequently in a number of localities slopes which had become permanent and were covered with a dense growth of vegetation were again disturbed and subjected to the action of tropical downpours. It was expected, therefore, that more trouble and annoyance than usual from this cause would be experienced within the next year or two subsequent to the widening of the upper levels of the canal, and experience during the past year shows that this opinion has been realized.

During the fiscal year ending June 30, 1910, several breaks occurred in the banks of the canal between the north end of the native village of Culebra and a point about 1,200 yards south of Gold Hill. These breaks occurred where the underlying rock was of poor quality and intersected by vertical seams or seams sloping toward the canal. Where the breaks occurred the upper surface of the broken portion of the bank usually remained approximately horizontal, settling nearly vertically. The enormous weight of this broken portion of the bank, receiving no support from lateral cohesion, forces up and displaces laterally the material lying directly below in the bottom or on the berms of the canal. This bottom material is sometimes forced up to a vertical height of from 10 to 20 feet. As the material thus forced up is dug away by steam shovels, the upper portion of the broken bank gradually settles and moves toward the axis of the canal, continuing to do so until the entire broken portion is removed, when trouble at that point ceases.

Of the slides proper the most important is the Cucaracha slide, described in previous reports. The total area embraced in this slide since the commencement of operations is 47.1 acres. Prior to July 1, 1909, 1,125,017 cubic yards of material had been removed from this slide, and 639,239 cubic yards were removed during the fiscal year. (See Pl. 104 and photographs, Pls. 33 and 34.)

The next largest slide is located on the west bank of the canal where the village of New Culebra was located, and is caused by the sliding of a large French dump into the canal. The area involved amounts to 7.3 acres. Prior to July 1, 1909, 118,024 cubic yards had been removed, and 327,540 cubic yards were removed during the fiscal year. (See Pl. 105.)

The third slide covers an area of 4.6 acres and is located on the east bank of the canal directly opposite the Whitehouse yard. Previous to July 1, 1909, 50,800 cubic yards of material had been removed from this slide and 110,000 cubic yards were removed during the present fiscal year. (See photograph, Pl. 40.)

The fourth slide covers an area of 1.7 acres and is situated on the east bank of the Obispo diversion at La Pita Point, where the west slope of a hill broke away and commenced to slide toward the Obispo diversion, threatening to close the same. Prompt steps were taken to remove this material before it could affect the diversion, and up to June 30, 1910, 15,608 cubic yards had been removed. The efforts

at this point were successful, and no material from this slide has reached the diversion.

With but three exceptions the amount of material involved in breaks in the banks has been small. The breaks in question are as follows:

(*a*) The largest break occurred on the west bank of the canal at the town of Culebra. The total broken area covered 10½ acres. Prior to July 1, 1909, 675,634 cubic yards of material had been removed and 1,005,388 cubic yards were removed during the fiscal year. (See photographs, Pls. 35, 36, and 37.)

(*b*) The second largest break, covering an area of 11½ acres, is on the east side of the canal directly opposite that just described. Prior to July 1, 1909, 166,018 cubic yards of material were removed from this break, and 314,184 cubic yards were removed during the fiscal year. (See photographs, Pls. 38 and 39.)

(*c*) The third break is that already mentioned, which occurred at La Pita Point and which permitted the waters of the Obispo diversion to flow into the canal for a period of three days. This break aggregates about 40,000 cubic yards, none of which will be removed until the next dry season. (See photographs, Pls. 24 and 25.)

It will thus be seen that considering the slides and breaks above enumerated, 2,135,493 cubic yards of material had been removed prior to July 1, 1909, and 2,411,959 cubic yards were removed during the fiscal year ending June 30, 1910. The total amount of material removed from all slides and breaks in the central division during the fiscal year ending June 30, 1910, amounted to 2,649,563 cubic yards. Photographs of the principal slides and breaks accompany this report.

COST OF EXCAVATION.

The average cost of the various items of expense in connection with excavation is shown in the following table, giving comparison with the fiscal years 1908 and 1909:

Class of work.	Fiscal year—		
	1908.	1909.	1910.
Loading:			
Steam shovels	$0.1150	$0.1001	$0.0888
Hand		.3993	.3442
Drilling and blasting	.1413	.1149	.1190
Transportation	.1854	.1452	.1522
Dumps	.1344	.0911	.0657
Tracks	.1190	.0838	.1001
Division office and supervision	.0163	.0114	.0150
General surveys	.0008	.0001	.0003
Clearing site	.0004	.0048	.0046
Division structures	.0002	.0012	.0013
Drainage and sumps			.0052
Total division cost	.7128	.5517	.5416
General expense and administration expense			.0652
Plant arbitrary[a]			.1300
	.7128	.5517	.7368

[a] This arbitrary is intended to absorb the entire cost of all plant by the time that work is completed.

NOTE.—Yardage figures for the fiscal year ending June 30, 1910, used in determining the above costs are as follows:

	Cubic yards.
Shovel excavation	17,558,364
Hand excavation	116,440
Total	17,674,804

It will be noted that the total division cost does not include plant nor overhead charges, such as pro rata cost of chairman and chief engineer's office, the disbursing office, the examiner of accounts' office, and the Washington office, but that the grand total cost of $0.7368 for the fiscal year 1910 includes these items and every other item chargeable against canal construction within the limits of the central division, although they are not given for the fiscal years 1908 and 1909, being then added in the chairman's office.

The cost of drilling and blasting as shown on the table has been distributed to cover the total number of cubic yards of excavation, but to get the real cost it should be applied to the material actually mined, which amounts to 12,158,996 cubic yards, which would make the cost when thus applied $0.1727 per cubic yard.

The increase in the cost of tracks is due to the fact that prior to July 1, 1909, all track material was charged to plant, but since that time has been absorbed in the work as purchased.

It will be noted that the division cost per cubic yard is $0.0101 less than during the fiscal year 1909, a satisfactory showing when the increased depth and decreased width of the cut and the unusually heavy rainfall are considered.

COAL AND FUEL OIL CONSUMED.

The total quantity of coal used during the fiscal year amounted to 187,326 long tons. Coal is the only fuel used except at the following pumping stations, at which points 21,425.40 barrels of oil was used during the fiscal year: Cucaracha, Mount Zion, Camacho, Gorgona, and Tabernilla.

STEAM-SHOVEL REPAIRS.

Since November 5, 1907, the central division has had a force of boiler makers, pipe fitters, and machinists, with the necessary helpers, working in the cut at night repairing steam shovels, and it has been found by experience that greater efficiency can be obtained in steam-shovel work if all repairs possible are made in the field without sending the steam shovel to the shop for general overhauling. Since the organization of this steam shovel night-repair gang, circles and booms, dippers and dipper sticks, A-frames, hoisting drums, main engine shafts, propelling shafts, swinging drums, intermediate shafts, water tanks, feed pumps, trucks, and in one or two cases, steam-shovel boilers have been changed in the cut. In fact, it is the practice to replace everything except the base castings, the deck of the shovel, and the boilers in the field.

In the interest of economy, and by direction of the chairman and chief engineer, the repairing of steam shovels and the manufacture and repair of steam shovel parts for the entire canal were transferred to the central division, effective October 1, 1909. In order to handle this work, the Empire shops were transferred from the mechanical division to the central division and all other mechanical work, formerly handled at the Empire shops, was transferred to the Gorgona shops. Prior to this date, the mechanical division handled all shop repairs to steam shovels and the two other construction divisions handled their own repair parts and field repairs independently. The other

divisions still handle their own field repairs, but the central division is held responsible for the standardization of repair parts and the maintenance of the greater part of the stock of these parts.

The average pay roll from October 1 to June 30 was $29,000, of which 19.5 per cent approximately was for central division field repairs, 52 per cent for shop repairs for the central division, 9.5 per cent shop repairs for other divisions, and 19 per cent for manufacturing for all divisions.

The total number of steam shovels repaired in the Empire shops for the period above mentioned was 33 and the average time each was in the shop was thirty days. The average number of shovels repaired in the cut each night was 15, and the average number of men employed in the night-repair gang in the cut was 13 gold and 32 silver men.

AIR AND WATER SERVICE.

During the fiscal year, in furnishing air connections for drills and other purposes 1,838,128 feet of pipe were laid, 3,040 feet of pipe were repaired, 1,746,480 feet of pipe were removed, and 22,160 feet of pipe were placed.

In furnishing water connections for steam shovels, orange peel and clam shell cranes, and for other purposes 2,389,296 feet of pipe were laid, 20,540 feet of pipe were repaired, 2,211,270 feet of pipe were removed, and 14,230 feet of pipe were replaced.

MUNICIPAL WORK.

During the fiscal year ending June 30, 1910, municipal work was carried on as in the past, the principal items of work performed being as follows:

Water pipe:		
Laid	feet	19,007
Replaced	do	5,847
Removed	do	7,107
Relaid	do	1,600
Sewer pipe:		
Laid	do	6,901
Replaced	do	1,193
Relaid	do	1,314
Sanitary work:		
Regrading ditches	linear feet	116,028
Ditches dug	do	17,149
Cleaning ditches	do	1,453,841
Tile drains laid	do	7,289
Concrete gutters made	do	6,690
Cleaning concrete drains	do	56,441
Clearing	square yards	123,597
Miscellaneous:		
Rock crushed	cubic yards	7,488
Concrete pipe made	linear feet	1,967
Drains cleared	square yards	4,802

ROAD BUILDING.

A wagon road 8 feet wide was constructed from Empire to the Las Cascadas plantation, a distance of 2.61 miles, and was completed on October 31, 1909. Forty-two per cent of the cost of the construc-

tion of this road was to be borne by the plantation company. This road opened up a very rich agricultural district and it is believed that in time, other plantations will be established along the line of this road, and that it will be extended to Las Cruces, a native town on the Chagres River.

The construction of the road between Empire and Paraiso was continued throughout the year and was 75 per cent completed on June 30, 1910.

The construction of a road between Empire and Gorgona was continued throughout the year and was 52 per cent completed on June 30, 1910.

With the completion of the Empire-Paraiso road, the Empire-Gorgona road, and the Panama-Corozal road across Miraflores dumps, a highway will be opened up from Panama City to Gorgona, a distance along the line of the railroad of 18.87 miles. The wagon road makes more detours and is correspondingly longer.

The following work was accomplished in connection with the maintenance of roads and cinder paths during the fiscal year:

Roads, maintenance:		
General repairs	square yards..	144, 556
Ditches cleaned	cubic yards..	142, 666
Cinder paths:		
General repairs	square yards..	20, 921
Paths made	linear feet..	5, 718

WATERWORKS.

The use of the Rio Grande, Camacho, and Carabali reservoirs for the purpose of supplying the various settlements with water was continued throughout the year and the pumping stations at Paraiso, Cucaracha, Mount Zion, Camacho, Gorgona, Tabernilla, and Bohio were operated during the year. The pumps at Bas Obispo and Chagres were held for emergency use.

Approximately 282,681,512 gallons were consumed by the central division from the Rio Grande Reservoir, which is operated by the Pacific division. The daily average consumption from the Camacho Reservoir was 2,000,000 gallons. The daily average consumption from the Carabali Reservoir was 975,000 gallons.

The total number of pumps in service at the different pumping stations was 22. The daily average number of pumps in operation at the various stations was 18. The daily average number of gallons pumped at the different pumping stations was 2,697,168; total for the year 984,466,454 gallons. The daily average number of gallons condensed at the various stations was 9,754 and the total for the year 3,560,131.

During the fiscal year the summit of drainage was moved to a point in the canal opposite Empire. All water entering the canal south of this point now drains into the Pacific Ocean. All water which enters the cut north of this point is pumped into the Chagres River. At the close of the fiscal year three duplex pumps, 16 by 22 by 18 inches, capacity 4,200 gallons per minute each; two Wagner duplex pumps, 16 by 8 by 12 inches, capacity 445 gallons per minute; one Worthington centrifugal pump, 24-inch discharge, capacity 18,000 gallons per minute; and two French centrifugal pumps, 17-inch discharge, capacity 7,000 gallons per minute each, were in operation

at the sump at Bas Obispo for the purpose of pumping water from the north end of the cut into the Chagres River. The piston pumps are arranged to operate by air or steam so that they can work under water for a considerable time.

EMPIRE SUSPENSION BRIDGE.

The construction of the suspension bridge across the canal at Empire was completed July 31, 1909. This bridge is supported by four galvanized steel cables $2\frac{3}{4}$ inches in diameter, strung over two wooden towers 60 feet high. The span is 600 feet between the towers, and the bridge is 8 feet wide. This bridge was constructed for the purpose of carrying air and water mains across the canal, and it is connected with a wagon road leading to the Las Cascadas Plantation and Paraiso.

LABOR SITUATION.

During the fiscal year of 1910 the labor situation was quite satisfactory, the supply of laborers being greater than the demand. This is largely due to the fact that a number of noncontract Spanish and Italian laborers have come to the Isthmus looking for work. In fact, so many of these men have been employed on the Isthmus that it was necessary during the fiscal year just passed to discharge a number of these noncontract laborers in order to take care of the laborers with whom the United States had contracts.

By far the larger number of laborers in the central division are West Indian negroes, but the percentage of Spaniards and Italians remains about the same as during the previous fiscal year. The average daily number of laborers employed in the central division for the fiscal year just ended was 8,021.

CHANGES IN ORGANIZATION.

On October 1, 1909, the Empire shops were transferred to the central division. The force transferred with these shops and the former steam shovel repair gang were consolidated and placed under the superintendent of steam shovel repairs.

The assistant engineer's office at Gorgona was abolished October 4, 1909, and the work for that district placed in charge of the assistant engineer at Las Cascadas.

The position of trainmaster was abolished on March 23, 1910.

The following changes became effective May 1, 1910:

The five construction districts were consolidated into four, as follows:

Pedro Miguel district.—Extending from bridge $57\frac{1}{2}$, south.

Culebra district.—Extending from bridge $57\frac{1}{2}$ to Empire Suspension Bridge.

Empire district.—Extending from Empire Suspension Bridge to Chagres River at Gamboa.

Chagres district.—Extending from Chagres River at Gamboa to Gatun dam.

The position of general superintendent of construction was created, as the position of assistant division engineer will be abolished on the date that the present assistant division engineer's resignation becomes effective.

CHANGES IN PERSONNEL.

Daniel E. Wright, appointed assistant engineer, effective August 9, 1909, vice George H. Ruggles, transferred to civil administration department; grade changed to superintendent of municipal work, September 1, 1909.

R. W. Hebard, assistant engineer, resigned, effective October 2, 1909.

George A. Greenslade, appointed general superintendent of construction, effective May 1, 1910.

James W. Sneed, appointed superintendent of construction, Chagres district, and John V. Donahue, appointed assistant superintendent of construction, Chagres district, effective May 1, 1910, on account of consolidation of the five construction districts into four.

James M. Hagan appointed superintendent of construction, Empire district, effective May 11, 1910, vice D. E. Crowley, resigned.

Collins P. Gibson appointed assistant superintendent of Empire district, effective May 11, 1910, vice J. M. Hagan, promoted.

L. K. Rourke, assistant division engineer, resigned, to take effect at the expiration of the forty-two days' leave with pay granted him beginning May 31, 1910.

Respectfully submitted.

D. D. Gaillard,
Lieutenant-Colonel, Corps of Engineers, U. S. Army,
Member of Isthmian Canal Commission,
Division Engineer, Central Division.

Col. George W. Goethals,
Corps of Engineers, U. S. Army,
Chairman and Chief Engineer,
Isthmian Canal Commission, Culebra, Canal Zone.

VIEW SHOWING COMBINED DIKE AND DUMP FROM EAST BALBOA TO NAOS ISLAND, PACIFIC OCEAN.

CULEBRA CUT, LOOKING NORTH FROM A POINT OPPOSITE CONTRACTORS HILL, JUNE 30, 1910.

CULEBRA CUT, OPPOSITE TOWN OF CULEBRA, LOOKING NORTH, JUNE 10, 1910, AFTER HEAVY RAIN.

CUT AT EMPIRE, LOOKING NORTH. IN THE UPPER RIGHT-HAND CORNER IS SEEN THE BREAK IN THE ROCK BANK WHICH LET THE OBISPO DIVERSION INTO THE CANAL FOR THREE DAYS.

CUT BETWEEN EMPIRE AND LAS CASCADAS, LOOKING SOUTH FROM A POINT JUST NORTH OF THE BREAK IN THE BANK SHOWN IN PLATE 24.

THE CUT AT BAS OBISPO, LOOKING SOUTH, JUNE 30, 1910.

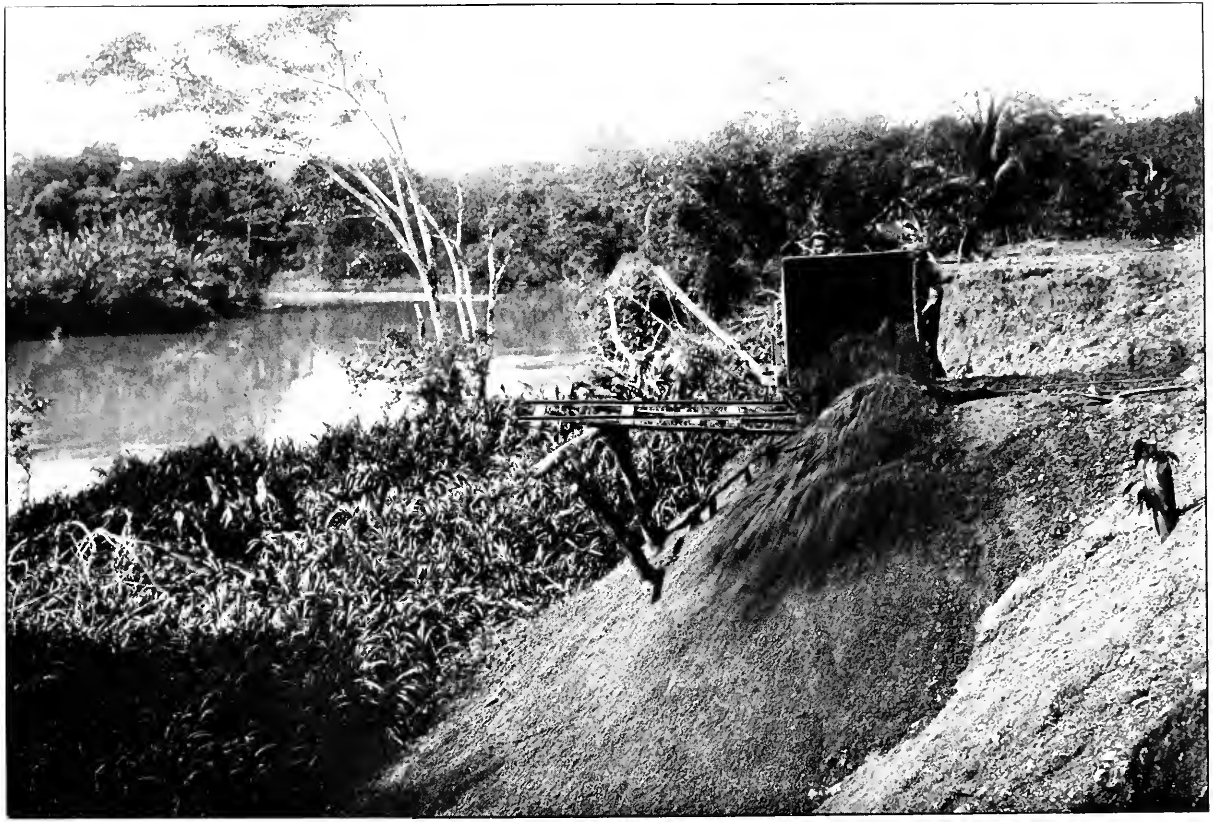
THE CUT AT BAS OBISPO DURING FLOOD OF NOVEMBER 19, 1909, LOOKING NORTH. STEAM SHOVELS SUBMERGED.

THE CHAGRES RIVER BREAKING THROUGH PROTECTION DIKE AT POINT ONE, NOVEMBER 19, 1909.

POINT TWO, LOOKING NORTH, SHOWING DEPOSITS OF SAND AND GRAVEL BROUGHT DOWN BY HIGH FLOODS IN NOVEMBER AND DECEMBER, 1909.

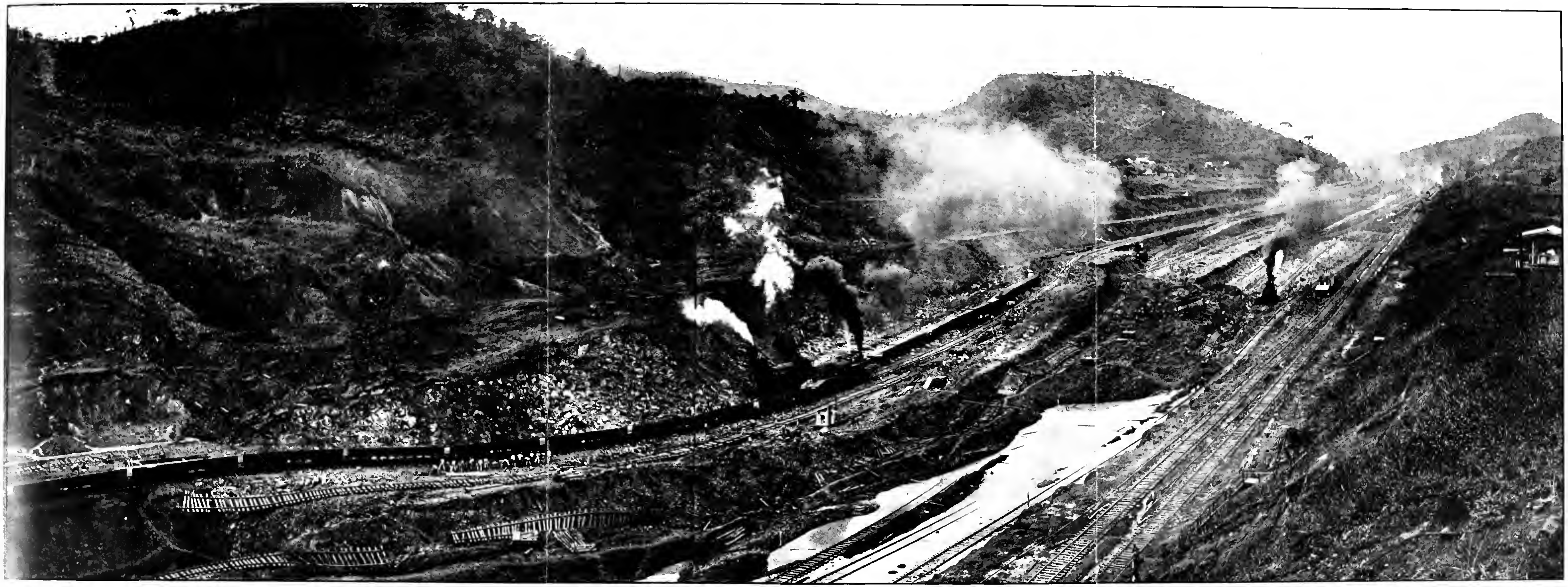
STEAM SHOVEL COMMENCING WORK AT POINT FOUR, JUNE 20, 1910, SHOWING TWO OLD FRENCH LADDER DREDGES IN THE FOREGROUND.

CONTRACT HAND WORK NEAR BOHIO, JUNE, 1910. WORKMEN ARE USING OLD FRENCH DECAUVILLE PUSH CARS ON PORTABLE TRACK.



HAND WORK NEAR BOHIO BY CONTRACTORS, SHOWING METHOD OF DUMPING MATERIAL.

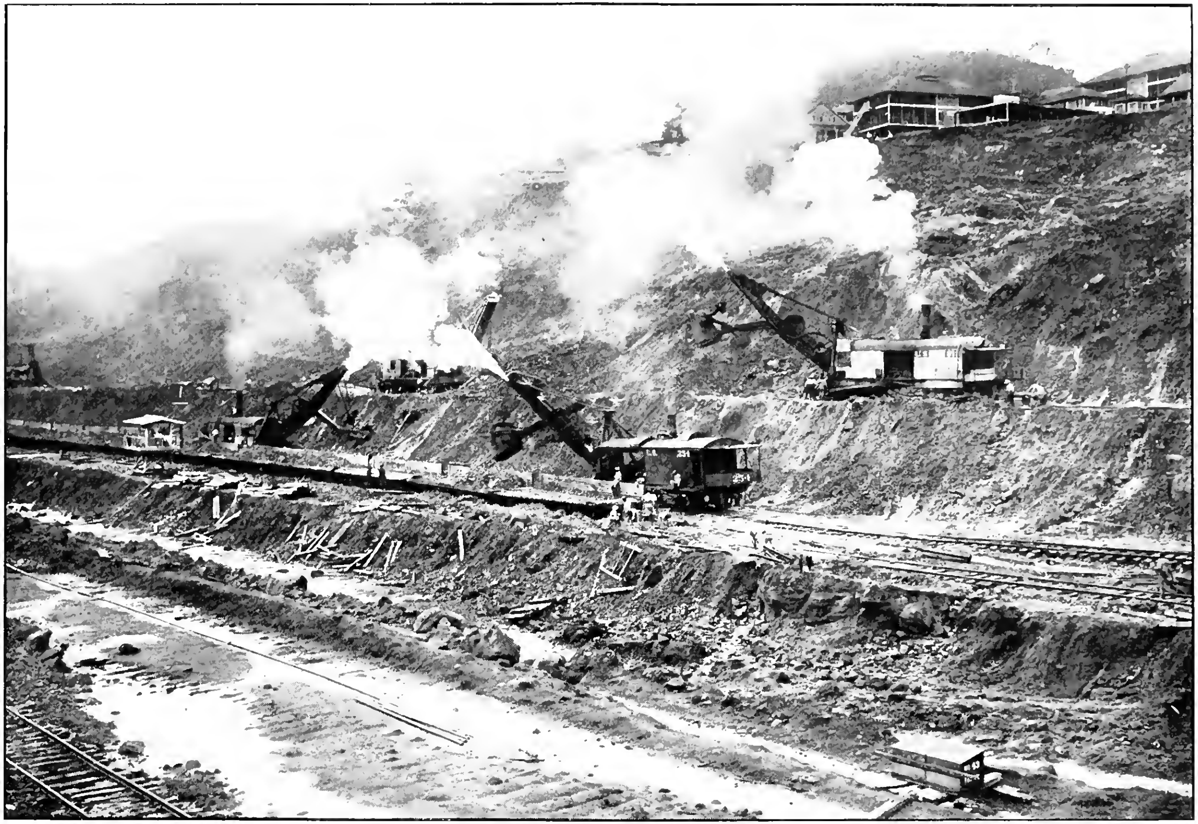
CUCARACHA SLIDE, JUNE 21, 1910. THE TOTAL AREA INVOLVED IN THIS SLIDE SINCE THE COMMENCEMENT OF OPERATIONS IS 47.1 ACRES.



CUCARACHA SLIDE, LOOKING SOUTH, JUNE 23, 1910. SHOWING HOW THE WEIGHT OF THE BROKEN BANK ON THE LEFT HAS PUSHED MATERIAL INTO THE CUT, COMPLETELY STOPPING UP THE PIONEER DRAINAGE CUT

BREAK IN THE WEST BANK AT CULEBRA, LOOKING SOUTH TOWARD GOLD HILL, JUNE, 1910.

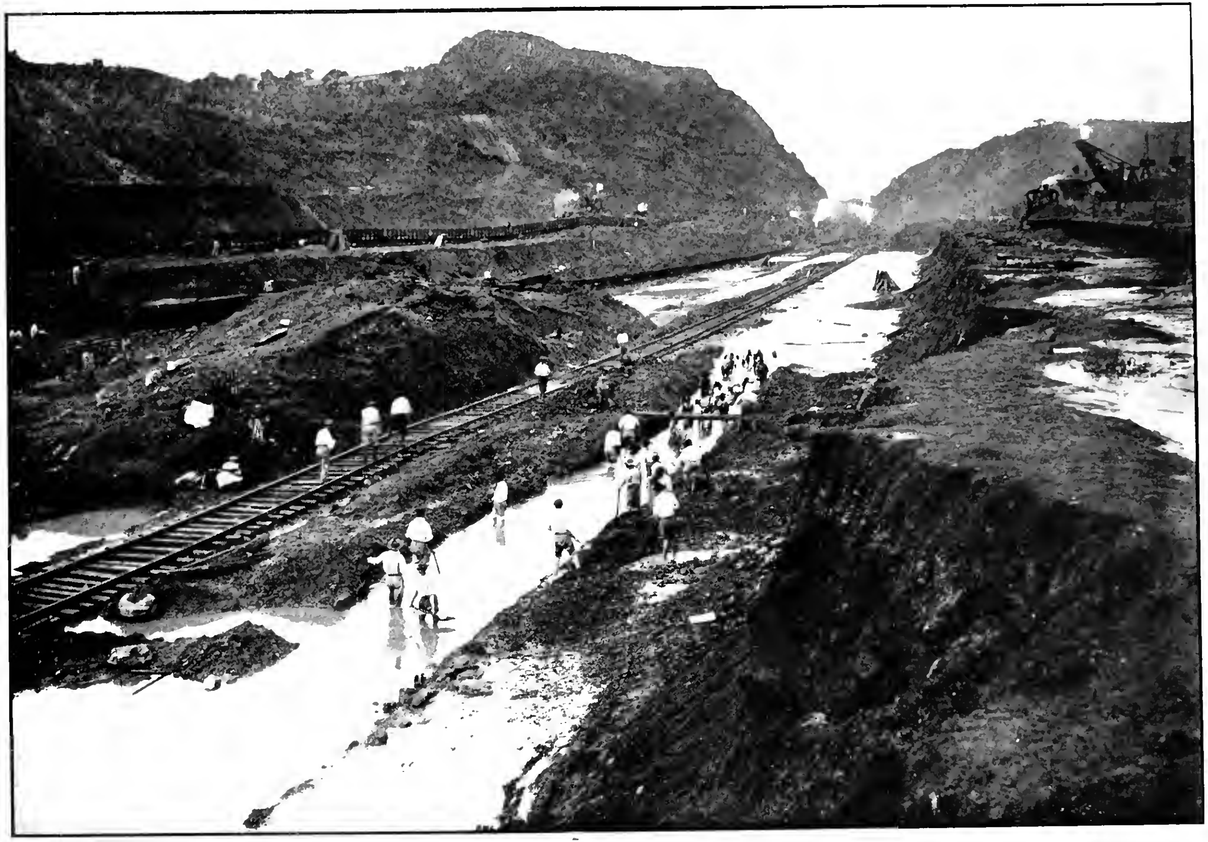
BREAK IN THE WEST BANK OF THE CANAL AT CULEBRA, OCTOBER, 1909.



BREAK IN THE WEST BANK AT CULEBRA, OCTOBER 16, 1909, SHOWING FOUR STEAM SHOVELS WORKING ON THE BROKEN AND MOVING MASS. THE TWO UPPER SHOVELS ARE CASTING MATERIAL OVER THE BERM TO BE LOADED BY THE TWO LOWER SHOVELS INTO THE LIDGERWOOD TRAIN.

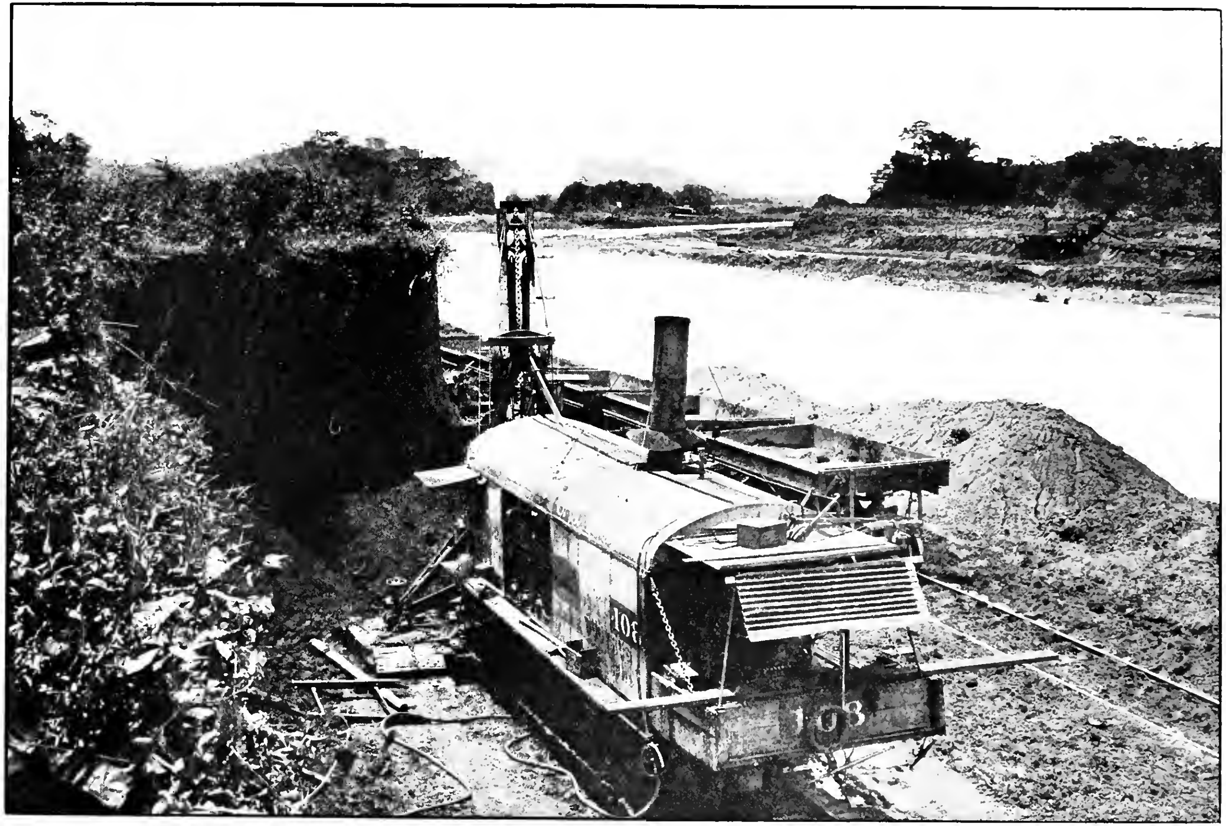
BREAK IN THE EAST BANK OF THE CANAL OPPOSITE CULEBRA, JUNE, 1910.

PLATE 39.



BREAK IN THE EAST BANK AT CULEBRA, SHOWING HOW THE PRESSURE OF THE BROKEN BANK, SHOWN IN PLATE 38, HAS RAISED THE BOTTOM, FOR A SHORT DISTANCE, TO A HEIGHT OF 18 FEET ABOVE ITS ORIGINAL LEVEL.

SLIDE IN EAST BANK OF THE CANAL OPPOSITE WHITE HOUSE YARD, JUNE 21, 1910.



EXCAVATION AT EAST MAMEI, LOOKING SOUTH, JUNE, 1910.

APPENDIX E.

REPORT OF S. B. WILLIAMSON, DIVISION ENGINEER, PACIFIC DIVISION.

Isthmian Canal Commission,
Department of Construction and Engineering,
Pacific Division, Office of Division Engineer,
Corozal, Canal Zone, July 28, 1910.

Sir: I have the honor to submit the following report of operations in the Pacific division during the fiscal year ended June 30, 1910:

Division Organization.

The division extends from mile 39.53, immediately north of Pedro Miguel, to deep water in the Pacific Ocean, a distance of 11 miles, and is subdivided as follows: First district—locks, dams, and dry excavation; second district—dredging, hydraulic excavation, Balboa shops, and shipways; third district—municipal and sanitary work; fourth district—Ancon quarry.

The present organization is shown by districts on Plate 142.

During the year, Mr. A. I. Campbell resigned the position of resident engineer of the first district and was succeeded by Mr. W. B. Corse on December 27, 1909.

A summary of the principal items of work performed is given in Table 1.

Table 1.—*Principal items of work performed in year ended June 30, 1910.*

Class of work.	Unit.	Quantity.
Dry excavation:		
Work	Cubic yards	1,269,866
Plant	do	241,961
Dredge excavation:		
Work	do	6,990,391
Plant	do	65,752
Explosives used (dynamite)	Gross tons	323.68
Rock drilling	Lineal feet	794,032
Channeler drilling	Square feet	117,972
Wash drilling	Lineal feet	51,963
New track laid	Miles	33.95
Dam filling	Cubic yards	372,184
Pile trestle driven	Lineal feet	3,885
Frame trestle constructed	do	4,800
Concrete placed	Cubic yards	176,923
Rock crushed	do	242,145
Buildings erected	Number	19
Buildings repaired	do	1
Roads built	Miles	0.42
Roads maintained	do	4.26
Drains and ditches dug	Lineal feet	39,054
Drains and ditches cleaned	do	460,213
Water pipe laid	do	58,635
Sewer pipe laid	do	30,750
Clearing and grubbing	Acres	62.85
Daily average of laborers employed	Number	4,446

First District.

LOCKS, DAMS, AND DRY EXCAVATIONS.

[W. B. Corse, resident engineer.]

Concrete-Handling Plant.

A change in the location of the Pacific locks delayed the designing of a construction plant until the early part of the year 1908. After completing the plans and specifications, tenders were invited on August 8, 1908, for manufacturing and delivering the machinery, and a contract awarded to the Wellman-Seaver-Morgan Company, of Cleveland, Ohio, on May 8, 1909.

This contract provided for the construction of eight cantilever cranes, four each of different types, designated, respectively, as Berm and Chamber cranes. These machines, differently arranged, will be used for placing concrete at both Pedro Miguel and Miraflores.

The high and unstable banks flanking the former site made it necessary to develop the handling plant in a longitudinal direction, by placing the mixing machinery and storage in the forebay, introducing a narrow-gauge road for transporting the mixed concrete to the placing machines located in the lock chambers. At Miraflores the handling of concrete is materially simplified as the nature of the ground admits of placing the storage piles and mixing machines on both sides of the lock pit, thus dispensing with the narrow-gauge road.

As the plant is now in operation at Pedro Miguel, this installation, shown on Plates 108 and 109, will be described first:

Pedro Miguel Handling Plant.

The essential features of the installation at Pedro Miguel are:

First. Storage trestles, for unloading and storing sand and stone.

Second. Berm cranes, for handling raw material and mixing concrete.

Third. Narrow-gauge road, for transporting concrete.

Fourth. Chamber cranes, for placing concrete.

STORAGE TRESTLES.

In the forebay of the locks framed trestles have been erected on both sides of and parallel to the canal axis; each has an average height of 28 feet and a length of 800 feet available for storage.

Sand and crushed stone are delivered on the trestles in trains made up of 12-yard dump cars, and the former is dumped on the outside and the latter on the inside in order to minimize the average distance of conveying the aggregates to the mixers. The total storage capacity is 45,000 and 55,000 cubic yards of sand and stone, respectively, which will supply the mixers for seventeen days of eight hours.

BERM CRANES.

Two berm cranes only are used at Pedro Miguel, and are installed between the trestles on two parallel 5-foot gauge tracks, 50 feet centers. The cranes are entirely of steel and consist of a tower 50 by

40 feet, supporting balanced cantilever arms that extend well over the storage trestles with ample clearance for a locomotive.

From the lower chords of the cantilever trusses are hung continuous trolley tracks equipped with two trolleys—one for each arm—arranged to operate $2\frac{1}{2}$ cubic yard Hulett excavating buckets, by means of which sand and stone are taken from storage and conveyed to bins located on the crane towers. There are four bins, each of 15 cubic yards capacity; two being used for stone and two for sand. Beneath the bins is a cement floor 2,000 square feet in area on which may be stored 6,000 bags of cement. Two cement hoppers of 10 barrels capacity each are hung from this floor.

Cement is delivered direct from box cars on an elevator attached to the tower framing and deposited by the latter on a horizontal conveyor running across the cement floor to the gratings over the hoppers, but the bags of cement may be taken off before reaching the hoppers and stored on the floor. The bins and hoppers are equipped with chutes which discharge into either one or both of the measuring hoppers that are attached to the two concrete mixers located lower down on the towers.

The mixers are 2-yard cube machines operated by electric motors, and are provided with long spouts for dumping direct into buckets on the narrow-gauge cars alongside. Each mixer is provided with an electrically operated recording instrument which shows graphically the time consumed in mixing each batch. The water required for mixing is supplied through automatic measuring tanks placed on the towers.

Power for operating the cranes is transmitted by an overhead line from the Miraflores power house to a substation at Pedro Miguel, where it is converted into 550-volt direct current by two 500-kilowatt rotaries and supplied to the cranes through a feeder rail supported on brackets attached to the cross-ties of one of the crane tracks. All motors, except for the concrete mixers, are in a machinery house located on top of the tower truss. All operations, however, are controlled by master switches in the cabs of the trolleys, so that the operator is always immediately over and in plain view of the bucket. A 65-horsepower compound-wound motor geared through two reductions to the cable drum is used for hoisting, and a 21-horsepower compound-wound motor for trolleying. In both of these movements dynamic braking is used. The elevator and conveyor are driven by a 15-horsepower compound-wound motor and each mixer by a 40-horsepower shunt-wound motor. One of the hoisting motors is also used for traversing the crane by connecting through friction clutches to the traversing drums after having disconnected from the hoisting drum, the arrangement being such that the two movements of hoisting and traversing can not be accomplished at the same time.

NARROW-GAUGE ROAD.

A narrow-gauge railroad is used for transporting mixed concrete from the berm to the chamber cranes. The track system is shown on Plate 108 and the difference in elevation between the forebay and bottom of lock chambers is overcome by means of trestles with a grade of 2.5 per cent. The tracks are laid with 70-pound steel rails, which enables the locomotives to attain a greater rate of speed than

would be safe on the light rail usually employed. The equipment consists of twelve 11½-ton Porter locomotives and 24 steel flat cars, all equipped with air; each car is large enough to hold two buckets of 64 cubic feet capacity. A train consists of two cars and each of the latter carries a bucket so placed that when alongside a berm crane the buckets may be filled from the corresponding mixers without moving the train. The trains alternate in going into the respective lock chambers and stop under the first chamber crane reached; the latter places an empty bucket on one of the cars and picks up a loaded one from the same car; the train then moves to the next crane, where the operation of exchanging buckets is repeated, after which it returns on the up track to the mixing cranes with the two empty buckets.

CHAMBER CRANES.

Four chamber cranes—two in each lock—are in service at Pedro Miguel. Their function is to place concrete, handle forms, and the steel or cast members that are embedded in the masonry. They are steel cantilever cranes made up of a tower 56 by 40 feet, carried on four heavy freight-car trucks which run on two 5-foot gauge tracks located on the floors of the locks. Each tower supports a cantilever arm 53 feet 6 inches long, extending over the center wall, and one 81 feet 6 inches long, extending over the side wall. A continuous trolley runway 191 feet long is suspended from the cantilevers and lower truss of the tower; the trolley is designed to run the entire length of the runway and to handle a 64 cubic foot concrete bucket. All operations, including opening and closing the bucket, are controlled by the operator in the trolley cab. As in the case of the berm cranes the machinery is in a house on top of the tower and is accentuated by direct electric current supplied from the same source. For hoisting and trolleying 47-horsepower and 21-horsepower motors, respectively, are used and a 15-horsepower motor for traversing the entire machine; the latter is controlled by a switch so located that the operator may reach it from his cab when in a certain position.

Miraflores Handling Plant.

The Miraflores plant is shown on Plates 110 and 111, and includes the following:

First. Storage trestles, for sand and stone.

Second. Berm cranes, for handling raw material, mixing, and placing.

Third. Chamber cranes, for placing.

STORAGE TRESTLES.

At Miraflores the storage trestles are located on both sides of the lock site and under the outer arms of the berm cranes. Sand and stone are delivered in the same manner as at Pedro Miguel.

BERM CRANES.

Two berm cranes on each side of the locks will be used at Miraflores. They will consist of steel towers with cantilever arms extending over the storage trestles and booms 144 feet long projecting over the side

walls of the locks. Those at Pedro Miguel will be dismantled and reerected at Miraflores with the following modifications: One of the cantilever arms will be removed from each and used as the outer arms for the two additional cranes, and all four will be equipped with booms. The towers are equipped with bins, hoppers, and 2-yard mixers, as at Pedro Miguel, but the operation differs in that one excavating bucket operated on the cantilever supplies sand and stone, while the boom carries a trolley equipped with a 64 cubic foot concrete bucket, into which the concrete is dumped direct from the mixers. The boom is hinged and has a vertical range of 25 degrees and may swing horizontally through an arc of 50 feet. It will not be necessary to unhook the bucket from the boom trolley either to receive or discharge the concrete, which will be deposited directly in the side walls and into a transfer hopper, from which it is discharged into the chamber crane buckets to be conveyed to the middle wall. All operations are controlled from the trolley cabs, and the motors are the same as now in use at Pedro Miguel.

CHAMBER CRANES.

The chamber cranes at Pedro Miguel will be dismantled upon the completion of the work there and rebuilt at Miraflores. They perform the same functions as described for Pedro Miguel.

Pedro Miguel Locks and Dams.

The work performed during the year consisted in excavating, preparing the foundations of the locks, erecting the handling plant, placing concrete, and filling the west dam.

LOCK EXCAVATION.

At the beginning of the fiscal year the excavation for the Pedro Miguel locks was practically complete. Subsequently two slides occurred on the east side, which necessitated the removal of 75,299 cubic yards of earth and rock from the excavated chamber. The total amount was excavated by steam shovels, of which 1,087 cubic yards were placed in the toes of the dams.

Table 2.—*Pedro Miguel lock excavation.*

Month.	Working days.	Earth.	Rock.	Total.	Average number of shovels.	Average per day per shovel.	Rainfall.
1909.		*Cu. yds.*	*Cu. yds.*	*Cu. yds.*		*Cu. yds.*	*Inches.*
July	26	16,770	58,323	75,093	4.56	633	9.19
August	26	10,221	41,844	52,065	4.46	449	10.07
September	25	19,109	25,296	44,405	3.12	569	10.22
October	26	19,226	12,914	32,140	3.85	321	17.47
November	23	936	14,618	15,554	2.08	325	20.38
December	25	1,000	22,502	23,502	3.04	309	11.30
1910.							
January	25	....	23,520	23,520	3.64	258	1.82
February	21	....	3,686	3,686	0.40	439	0.50
March	....	....	....	....	....	....	1.46
April	26	....	2,070	2,070	0.14	569	5.16
May	25	....	3,830	3,830	0.37	414	13.24
June	26	....	2,070	2,070	0.22	362	14.42
Total	274	67,262	210,673	277,935	2.35	423	115.23

MINING.

The following work was performed in mining the material excavated:

Drilling with power drills	linear feet..	346,891
Drilling by hand	do....	62
Total		346,953
Explosives used	tons..	38.57

CONSTRUCTION TRACKS.

All construction tracks were maintained and moved when necessary. Fifteen and three-tenths miles of new track were laid.

LOCK FOUNDATIONS.

The preparation of the foundations necessitated removing the loose rock remaining after the steam shovel cuts, excavating 42 trenches 13 feet wide, 11 feet deep, and 137 feet long for the lateral culverts; also an area of 25,000 square feet to a depth of 5 feet below the floor level at the miter sills. The conditions and character of material were such that a greater portion had to be picked and shoveled by hand into buckets or skips and handled with locomotive cranes or derricks. A total of 64,084 cubic yards of rock was removed, of which 2,608 cubic yards were used in constructing the toes of the dams, 1,166 cubic yards of trap rock placed in the concrete, and 60,310 cubic yards wasted.

The following work was performed in mining the above material:

Drilling with power drills	linear feet..	346,891
Drilling with hand drills	do....	62
Total		346,953
Explosives used	tons..	15.3

ERECTING HANDLING PLANT.

All tracks required for the cantilever cranes, narrow-gauge equipment and for delivering sand, stone, and cement, were graded, laid, ballasted, the aggregate amounting to 1,300 feet of 5-foot gauge and 11,000 feet of narrow-gauge. There was also erected 3,525 linear feet of storage trestle and 1,400 linear feet of trestle for the narrow-gauge tracks. The delivery on the Isthmus of the structural material and machinery for the cranes began on September 22, 1909, and their erection started on November 6, 1909. One berm and two chamber cranes were completed on March 1, 1910, and the remainder on May 28, 1910.

In order to begin placing concrete before the regular handling plant was available, three one-half yard mixers were employed to mix concrete for the lower guide wall, and two of the 2-cubic-yard mixers, purchased for the regular plant, were temporarily installed to provide concrete for constructing the floors and lateral culverts. The small mixers have been transferred to Miraflores, and only one of the large ones is in operation at present; the other having been dismantled.

PLACING CONCRETE.

Concrete work was begun on the lower guide wall of the Pedro Miguel locks, September 1, 1909, with the temporary plant described above, and extended to the floor and lateral culverts of the west chamber in the following month. One-half of the regular plant, consisting of a berm and two chamber cranes, was placed in service on April 4, 1910, and began laying the west and center walls. The entire plant began operations on July 15, 1910.

About 1,656 cubic yards of large stone have been placed in the concrete. A portion of this was trap rock taken from the lock excavation and the remainder obtained from Ancon Hill at the quarry site. The total amount of concrete laid to June 30, including the large stone, is 166,868 cubic yards, distributed as follows:

Lower guide wall	cubic yards..	54,697
Floors and culverts	do....	23,782
West wall	do....	60,613
Center wall	do....	22,782
East wall	do....	4,994
Total		166,868
Large stone (included in above)	do....	1,656

The progress during the year is shown graphically on Plate 112, and the detailed performance of the temporary and regular plants, respectively, are given in the following tables:

TABLE 3.—*Performance of temporary concrete-handling plant, Pedro Miguel.*

Month.	Mixers used.		Working time (average per mixer).			Concrete placed (all mixers).			
	Average number.	Size.	Days of 8 hours.	Hours. Per day of 8 hours.	Hours. Total per 8-hour day.	Per day of 8 hours.	Per hour.	Total.	Per mixer hour.
		Cubic yards.				*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1909.									
July									
August									
September	1.00	2	5	5.48	27.42	92.40	16.85	462.00	16.85
Do	1.00	½	21	7.31	153.58	75.54	10.33	1,586.50	10.33
October	1.00	2	25	6.13	153.25	136.80	22.32	3,420.00	22.32
Do	1.46	½	29	8.12	227.97	133.74	16.47	3,755.50	11.28
November	1.00	2	23	6.14	141.17	152.26	24.80	3,502.00	24.80
Do	3.17	½	23	7.90	181.70	262.54	33.22	6,046.50	10.48
December	1.12	2	26	6.13	159.38	164.53	26.84	4,260.00	23.96
Do	3.73	½	26	8.45	219.70	343.46	40.66	8,932.00	10.90
1910.									
January	1.88	2	25	6.80	162.00	414.41	63.96	10,360.00	34.02
Do	3.12	½	25	8.01	200.25	277.80	34.66	6,945.50	11.11
February	1.91	2	23	7.15	164.45	347.81	48.65	8,012.00	25.47
Do	2.22	½	23	8.38	192.74	223.04	26.62	5,124.00	11.99
March	1.46	2	28	7.26	203.28	274.73	37.86	7,715.00	25.93
Do	1.93	½	27	8.23	222.21	200.00	24.30	5,388.50	12.59
April	1.10	2	10	5.95	59.50	93.80	15.75	938.00	14.32
Do	1.69	½	26	7.75	201.50	132.63	17.10	3,453.00	10.12
May	1.00	2	23	6.38	146.83	170.80	26.77	3,928.00	26.77
Do	1.82	½	23	6.74	155.02	170.20	15.91	2,474.00	8.74
June	1.00	2	27	7.87	212.59	244.78	31.08	6,609.00	31.08

TABLE 4.—*Performance of regular concrete-handling plant, Pedro Miguel.*

Month.	Mixers used.		Working time (average per mixer).			Concrete placed (all mixers).			
	Average number.	Size.	Days of 8 hours.	Hours. Per day of 8 hours.	Hours. Total.	Per day of 8 hours.	Per hour.	Total.	Per mixer hour.
		Cubic yards.				*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1909.									
July									
August									
September									
October									
November									
December									
1910.									
January									
February									
March	1.00	2	14	6.11	85.50	385.54	63.10	5,404	63.10
April	1.88	2	26	7.47	194.67	791.07	105.81	20,615	56.28
May	2.00	2	25	7.38	184.58	926.63	125.56	23,178	62.78
June	2.52	2	27	6.15	166.05	885.42	143.97	23,886	57.13

CONCRETE FORMS.

Wooden forms in built-up panels, 15 feet long and 6 feet high, as shown on Plate 113, are used in constructing the locks. The panels are made up of a series of uprights 14 feet long, secured together by waling strips and lagging; the latter is placed on the upper 6 feet only, the lower 8 feet of the uprights act as cantilevers and are anchored to the concrete previously placed. The anchor bolts extend into the masonry about 2 feet and are removed as the work progresses, leaving the anchor nut only embedded. After the battered portion of the wall is completed, one set of forms carries it to the full height and are then removed to another portion of the wall. Each panel is therefore used at least twelve times.

BACKFILLING.

Filling back of the west wall was begun about the 1st of June. The material is obtained from the Ancon quarry site and contains a large percentage of stones suitable for placing in the concrete. The object of this work is twofold, viz, to backfill, and select from the same, large stone for the concrete; the latter is conveyed from the backfill to the walls in buckets or skips by the chamber cranes. About 9,616 cubic yards of backfilling have been placed, from which 490 cubic yards of rock were taken for the concrete.

FILLING WEST DAM.

The west dam at Pedro Miguel is being constructed of earth excavated from the canal prism south of the locks. Material for the impervious portion is selected and deposited from dump cars in layers about 6 feet deep; each layer is thoroughly wet down and compacted. The toes inclosing the impervious core are made of all classes of waste material, a large percentage being rock. Within the year, 51,827 cubic yards have been added to the impervious portion and 41,964 cubic yards to the toes.

Dry Excavation in Prism.

From one to two steam shovels have been engaged in excavating the channel immediately south of the Pedro Miguel locks since September of the present fiscal year. A total of 99,703 cubic yards has been removed below the lock at Pedro Miguel. Of this total, 45,775 cubic yards were used in the dam core and the remainder placed in the toes or wasted elsewhere.

Table 5.—*Excavation in prism.*

Month.	Working days.	Earth.	Rock.	Total.	Average number of shovels.	Average per day per shovel	Rainfall.
1909.		*Cu. yds.*	*Cu. yds.*	*Cu. yds.*		*Cu. yds.*	*Inches.*
July							
August							
September							
October							
November							
December							
1910.							
January							
February	21.0	9,636	448	10,084	1.08	445	1.26
March	26.0	22,860		22,860	2.07	425	1.98
April	26.0	34,309		34,309	2.32	569	5.16
May	24.5	20,964		20,964	2.53	338	11.81
June	26.0	11,486		11,486	1.20	368	14.10
Total	123.5	99,255	448	99,703	9.20	2,145	34.31

Miraflores Locks and Dams.

The lock excavation and construction of the west dam and power house were continued during the year, and the work of preparing foundations, erecting concrete plant, and placing concrete begun.

DRY EXCAVATION.

Steam shovels were employed in excavating for the upper lock of the Miraflores flight. At the end of the year there remains to be excavated an inclined track only, on the west side, and the earth from several small slides. The total amount excavated within the year is 285,354 cubic yards. Of this, 157,483 cubic yards were placed in the dam toes and 121,080 cubic yards used as back filling.

Table 6.—*Dry excavation, Miraflores locks.*

Month.	Working days.	Earth.	Rock.	Total.	Average number of shovels.	Average per day per shovel.	Rainfall.
1909.		*Cu. yds.*	*Cu. yds.*	*Cu. yds.*		*Cu. yds.*	*Inches.*
July	26	8,932	31,585	40,517	3.69	422	10.27
August	26	2,197	32,197	34,394	2.88	459	6.46
September	25		31,056	31,056	2.32	535	11.85
October	25	3,725	20,084	23,809	2.15	443	17.53
November	23	1,122	16,160	17,282	1.67	449	22.43
December	26		18,323	18,323	1.61	438	14.53
1910.							
January	25		29,733	29,733	2.72	437	3.58
February	23	1,504	12,915	14,419	2.35	267	2.02
March	25		10,884	10,884	1.73	252	2.49
April							5.15
May							10.39
June	24	6,990	7,324	14,314	2.19	272	13.79
Total	248	24,470	210,261	234,731	2.33	397	120.49

MINING.

The following mining work was performed:

Drilling with power drills	linear feet	286,747
Drilling with hand drills	do	465
Total		287,212
Explosives used	gross tons	46.66

CONSTRUCTION TRACKS.

In addition to maintaining and moving tracks as required, 13.8 miles of new construction tracks were laid in connection with the work at Miraflores.

DREDGING.

The suction dredge *Sandpiper* worked in the lower lock site until December, 1909. Due to the large number of bowlders encountered the output was small and the performance of the dredge generally unsatisfactory. It was therefore transferred to the Atlantic Division, and the remainder of the material at Miraflores will be excavated hydraulically. The amount of material removed by the *Sandpiper* was 141,759 cubic yards.

TABLE 7.—*Performance of dredge Sandpiper at Miraflores.*

Date.	Total output.				Used for filling.	
	Per hour at work.	Per hour under steam.	Per day.	Per month.	Backfill.	Dam fill.
1909.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
July	96.25	74.80	1,636.37	26,182	6,116	14,679
August	140.61	108.94	2,156.13	51,747		48,793
September	93.36	70.90	1,540.40	33,889		30,500
October	77.02	58.62	1,319.00	21,104		18,994
November	29.07	22.09	519.80	8,837		7,953
December						
1910.						
January						
February						
March						
April						
May						
June						
Total				141,759	6,116	

LOCK FOUNDATION.

The work of preparing the foundation of the upper locks is 45 per cent completed and includes cleaning up the loose material, excavating for the lateral culverts and sumps above the miter sills. The work has been done with a Thew steam shovel and by hand, the total amount excavated being 39,381 cubic yards.

Drilling and blasting required the following amount of work:

Drilling with power drills	linear feet	107,810
Explosives used	gross tons	17.51

ERECTING HANDLING PLANT.

All tracks for supplying material to the berm cranes, and 1,400 linear feet of the crane tracks have been laid and ballasted on the east side of the lock site. The storage trestle on this side, which is 3.200

feet long, is 60 per cent complete and the storage of material begun. On the west side track laying and the erection of trestles for storage is in progress. Two berm cranes—one on each side—are completely assembled except for the cantilever arms now in use at Pedro Miguel. The east crane will shortly begin placing concrete in the east lock wall, being supplied temporarily by two mixers installed under the east storage trestle.

PLACING CONCRETE.

Placing concrete in the floors and lateral culverts of the upper locks at Miraflores was begun on June 1. The work is being done with 2½ cubic yard mixers, and the object is to complete the floors before the permanent plant is transferred from Pedro Miguel. The total amount of concrete laid to the end of the fiscal year is 1,630 cubic yards, all of which is in the floors.

CEMENT SHED.

The cement shed was completed in the past year and is in use. It has a capacity of 75,000 barrels. To date about 42 per cent of the cement used has passed through the storage shed; the remainder has been unloaded directly from box cars to the cement platform of the mixing cranes.

POWER HOUSE.

The reenforced concrete power house at Miraflores has been finished and is in operation. The building is 157 feet 6 inches long, 76 feet 6 inches wide, and the eaves are 39 feet above the generator-room floor, and beneath the latter is a basement. One end of the building and a portion of the turbine-room floor are of temporary construction, as the water turbines to be used in operating the canal will occupy this portion of the building and their type and weight are not yet determined. With this exception the building is reenforced concrete throughout. The boiler and turbine rooms are separated by a concrete partition wall 8 inches thick.

The boiler equipment consists of six nominally rated, 400-horsepower water-tube boilers, set in batteries of two, equipped with superheaters and induced draft.

The electrical equipment consists of three 1,500-kilowatt, 220-volt, 3-phase, 25-cycle turbo-generators; two 35-kilowatt, 125-volt turbo-exciters; one 30-kilowatt, 125-volt induction motor driven exciter, together with three rotary converters, condensers, switching apparatus, and all necessary turbine auxiliaries.

WEST DAM.

Since the removal of the suction dredge *Sandpiper* from the lock excavation there has been no material placed in the impervious core. A 20-inch relay pump, with 1,200 feet of discharge pipe leading to the dam core, has been installed for use in filling the dam in connection with the hydraulic plant described hereafter. About 120,910 cubic yards of impervious material were pumped into the dam in the past year, and 157,483 cubic yards of waste from the lock excavations were added to the toes.

Second District.

DREDGING, HYDRAULIC EXCAVATION, AND BALBOA SHOPS.

[W. G. Comber, resident engineer.]

Dredging.

The following dredges were operated during the past year:

Table 8.—*Dredges of Pacific division.*

Name.	Type of dredge.	Remarks.
Culebra	Suction dredge (seagoing)	Out of commission 22 days for repairs.
Cardenas	5-yard dipper dredge	Out of commission 43 days for repairs.
Gopher	French ladder dredge (marine)	Out of commission 94 days for repairs.
Badger	French ladder dredge	Out of commission 10 days for repairs.
Mole	French ladder dredge (marine)	Out of commission 19 days for repairs.
Marmot	French ladder dredge	

The *Culebra* was engaged throughout the year in deepening the channel from the entrance northward to station 2160.

The *Cardenas* was employed in removing the earth from the rock shoals between stations 2195 and 2285 so that the rock breaker and drill scow could operate; also in dredging the rock after it had been broken up.

The *Gopher* operated in the channel until November, when it was sent to Chame to dredge sand for the lock construction.

The *Badger* dredged in the channel from station 2113 south, working chiefly on the east side, and was also employed in excavating a channel to the hydraulic pumping station.

The *Mole* worked on the west side of the channel from station 2220 south and was also employed in cleaning off rock shoals and dredging broken rock. It replaced the *Gopher* when the latter was brought in for repairs.

The *Marmot* worked as far north in the channel as station 2099, dredging a narrow channel to be used as sumps for the hydraulic excavating pumps.

The monthly output of dredges was as follows:

Table 9.—*Dredging output, Pacific division.*

Month.	Culebra.	Sand-piper.	Car-denas.	Gopher.	Badger.	Mole.	Marmot.	Total.
	Cubic yards.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
1909.								
July	399,100	26.182	30.800	34,496	109,761	101,130	147,894	759,363
August	151,870	51,747	75,462	....	142,241	106,523	150,767	678,610
September	324,571	33,889	31,953	....	85,908	105,749	114,795	696,865
October	382,952	21,104	35,840	7,802	98,063	70,600	125,663	742,024
November	334,843	8,837	45,498	....	84,862	66,719	100,869	641,628
December	342.395	....	75,620	....	121,000	58,805	129,640	727,460
1910.								
January	261,767	....	27,391	....	39,092	52,590	128,096	518,936
February	39,152	....	28,550	....	79,865	46,450	121,940	315.957
March	149,959	....	49,870	....	98,420	50,227	121,453	469,929
April	261,350	....	42,660	....	93,680	40,285	98,972	536,947
May	259,991	....	46,288	....	76,420	12,025	89,785	484,509
June	271,079	....	37,600	....	52,972	29,750	92,514	483,915
Total	3,099,029	141,759	527,532	42,298	1,082,284	740,853	1,422,388	7,956,143

At the end of the fiscal year there remains 11,188,373 cubic yards of earth to be dredged south of the Miraflores locks. Three million thirty thousand two hundred and forty cubic yards of this will be dredged and 8,158,133 cubic yards excavated hydraulically.

Rock Excavation.

South of station 2142 all rock encountered in the prism will be drilled and blasted, or otherwise broken up, and removed by the dredges. The rock in this portion of the canal lies in separate shoals of comparatively small area and volume, as shown in the following table:

Table 10.—*Subaqueous rock excavation.*

Month.	Location (station).	Area of shoal.	Volume excavated.	Method of breaking.
1909.		*Square feet.*	*Cubic yards.*	
July	Shoal 2225	15,000	800	Broken by Vulcan.
August	Shoal 2225	20,000	4,470	Cleaning rock from shoal.
September				
October	2164+75–2161+75	15,000	9,806	Loose rock picked up by Badger.
	Shoal 2250	48,000	2,500	After first attack by Vulcan.
	Shoal 2225	22,000	4,320	Recleaning shoal and dredging loose rock.
November	Shoal 2285	29,600	1,046.3	After first attack by Vulcan.
December				
1910.				
January	Shoal 2285	30,400	3,266	After second attack by Vulcan.
	Shoal 2250	49,600	3,016.2	Do.
February				
March	Shoal 2285	35,200	4,411.2	After third attack by Vulcan.
April	Shoal 2225	22,200	5,600	After first attack by Vulcan.
	2195+45–2193	14,250	3,429	Broken by Star drilling and blasting.
May	Shoal 2285	36,250	3,276	After fourth attack by Vulcan.
	2200+50–2195	8,250	728	Broken by Star drilling and blasting.
	2206+25–2205+25	13,000	1,424	Do.
June	2205+25–2203+50	18,300	6,874	Do.
	2212+50	5,000	1,787	Do.
	2195–2197	7,000	5,150	Do.
	Shoal 2225	([a])	1,600	After second attack by Vulcan.
Total			63,503.7	

[a] Not finished.

Three methods are used in breaking the rock to a dredgable size, viz, drilling with well drills through the overlying earth, drilling below water with a drill scow, and breaking under water with a Lobnitz rock breaker. Blasting is necessary with the first two methods only.

Operation of Well Drills.

An average of 12 drills have been in operation during the year. With these a hole is sunk through the overlying earth through pipe casing and then drilled to the required depth into the rock. The holes in the rock are sprung before loading.

TABLE 11.—*Performance of well drills and dredges.*

Month.	Average number of drills.	Linear feet drilled.				Dynamite.	Rock.	
		Earth.	Rock.	Total.	Per drill.		Broken (estimated).	Dredged (actual).
1909.						Pounds.	Cu. yards.	Cu. yards.
July	11	5,382	2,964	8,346	759	10,091	9,587	....
August	11	3,943	2,930	6,873	625	15,972	12,250	....
September	10	2,229	2,318	4,547	455	20,814	14,825	....
October	9	3,103	2,272	5,375	597	19,716	23,383	....
November	10	3,104	1,392	4,496	450	25,866	21,916	....
December	10	4,195	1,715	5,911	591	27,018	23,170	....
1910.								
January	14	5,328	2,400	7,728	552	32,228	20,675	....
February	14	7,090	3,313	10,403	743	47,823	30,118	....
March	12	6,416	3,725	10,141	845	41,284	30,459	....
April	13	5,401	3,832	9,233	710	42,975	28,975	3,429
May	16	2,913	4,775	7,688	480	33,364	23,808	2,152
June	13	1,785	4,301	6,086	468	28,714	35,173	13,811
Total	12	50,889	35,938	86,827	7,236	345,865	274,339	19,392

OPERATION OF DRILL BARGE.

The drill barge *Teredo* has a strongly constructed steel hull, 112 feet by 36 feet 8 inches, with two longitudinal and six transverse water-tight bulkheads, dividing it into 21 compartments. Two of these amidships are used as water tanks and in others are located six fuel-oil tanks of 40 barrels capacity each. Timber spuds 24 inches square are located at each corner of the barge, each being operated by an independent engine with rack and pinion. The barge is maneuvered by means of four manila ropes attached to kedge anchors. Three drill frames, 38 feet high, are located along one of the gunwales and arranged to move lengthwise of the barge on rails, the movement being accomplished by an endless chain operated by hydraulic power. Each frame carries a slide to which is attached a 5½-inch rock drill. Each slide is operated by a hydraulic ram and may be moved vertically through 10 feet. Drill bars of unusual length are necessary owing to the great range of tide. The frames are supplied with steam from a central boiler through slip and swing jointed pipes. The drills may operate over a distance of 85 feet from one position of the barge. At present the holes are spaced 5 feet apart on lines 6 feet apart and are located by means of ranges ashore.

The barge began operations in March, 1910, and accomplished the following work prior to the end of the fiscal year:

TABLE 12.—*Performance of drill barge.*

Month.	Drilling.			Blasting.		Dredging.	
	Linear feet.	Hours worked.	Feet per hour.	Number of holes blasted.	Dynamite used.	Area covered.	Cubic yards dredged.
1909.					*Pounds.*		
July							
August							
September							
October							
November							
December							
1910.							
January							
February							
March	799	270	2.96	41	420	(a)	(b)
April	1,706	260	6.56	94	1,659	(a)	(b)
May	2,557	250	10.23	149	2,676	(a)	(b)
June	2,446	260	9.41	123	2,488	(a)	(b)
Total	7,508	1,040	7.22	407	7,243		

[a] Forty-nine thousand six hundred square feet area of shoal. [b] No dredging done.

OPERATION OF LOBNITZ ROCK BREAKER.

The rock breaker *Vulcan* is a device for breaking subaqueous rock by impact; the machinery is mounted on a steel hull, 100 by 28 by 8 feet, divided into water-tight compartments, some of which are used as fuel oil and water tanks.

The ram or cutter is a heavy compressed-steel spar fitted with a hardened-steel conical point and is alternately hoisted and allowed to drop of its own weight. The range of tide and depth of channel require the use of three sizes of ram, viz, 30, 40, and 56 feet long, weighing, respectively, 15, 16, and 19.5 tons. The hoisting is accomplished by means of a 2-inch steel cable attached to the top of the cutter and passing over a large sheave, supported vertically over the ram by an A frame 65 feet high; from the latter the cable leads to the drum of a powerful steam winch located on the deck and especially designed for continuous running. The winch is provided with automatic gear and a lubricated steel friction clutch, which allows the cable to follow the fall and hoists the cutter immediately after the blow is struck. The barge is maneuvered by a steam winch especially designed for paying in or out six wire ropes or chains, and is provided with quarters for the crew and an electric-light plant. Steam is supplied by a Scotch marine boiler.

After a rock shoal has been exposed by dredging the general practice is to attack the surface with the rock breaker at intervals of 4 feet each way, the points of attack being located by ranges ashore and permanent marks on the deck. The cutter is operated in one position until the limit of penetration, which averages 3.12 feet, is reached. After the entire area of the shoal has been gone over the rock breaker is removed and the broken rock dredged out; the operation of alternately breaking and dredging is repeated until the required depth is obtained.

The *Vulcan* was placed in commission in August, 1909, and its performance is shown in the following table:

TABLE 13.—*Performance of rock breaker.*

Month.	Rock breaker.						Dredges.	
	Holes.	Blows.	Total penetration.	Blows per hole. hole.	Penetration per blow.	Penetration per hole.	Area covered.	Cubic yards dredged.
1909.			*Feet.*		*Feet.*	*Feet.*	*Square feet.*	
July							15,000	800
August	140	3,763	447	27.02	0.12	3.19		
September	1,603	11,803	4,235	7.36	.36	2.64		
October	1,080	10,168	2,944	9.41	.29	2.73	48,000	2,500
November	1,436	5,020	3,793	3.51	.76	2.65	29,600	1,046
December	1,251	9,508	3,921	7.60	.41	3.13		
1910.								
January	1,578	9,663	4,623	6.12	.48	2.93	30,400 49,600	3,266 3,016
February	1,928	12,829	6,138	6.65	.48	3.18		
March	1,538	8,018	4,641	5.21	.58	3.02	35,200	4,411
April	1,908	13,164	5,210	6.90	.40	2.73	22,200	5,600
May	1,517	8,938	6,205	5.89	.69	4.09	36,250	3,276
June	1,988	13,362	7,629	6.72	.57	3.84	Unfinished.	1,600
Total	15,961	106,256	49,786	6.66	.47	3.12	266,230	25,515

Hours worked	1,462
Penetration per hour ... feet	34.05
Total service time ... hours	2,845
Penetration per hour ... feet	17.5

HYDRAULIC EXCAVATION.

For a distance of about $1\frac{1}{2}$ miles south from the Miraflores locks rock is found in the channel to be excavated, at an average elevation of minus 30 feet. The estimated quantity is 1,503,260 cubic yards, which is covered by 8,158,133 cubic yards of alluvial material averaging 38 feet in depth. It was manifestly impracticable to remove the earth and rock by dredging and subaqueous methods, as the requisite number of dredges, barges, drill scows, and rock breakers would have called for an unwarranted expenditure and could not have been assembled and placed in commission so as to complete the work in the allotted time. A careful study of the conditions showed that the rock may be excavated by steam shovels, in the dry, in a shorter time and at less cost than by any other method. This, however, is not true in regard to the overlying alluvial deposit, as steam shovels and other equipment were not available in sufficient number to remove it at the required rate, and in addition the maintenance of tracks would be difficult and expensive in this partly saturated material.

A hydraulic excavating plant was, therefore, selected as being the cheapest and most expeditious method of handling the loam, especially as it may be used to redeem about 450 acres of adjacent swamp belonging to the commission. Two principal operations are involved, viz, disintegrating the material and washing it to sumps by means of a water jet under high pressure, and lifting and conveying it through flumes by means of dredging pumps. The plant consists of the following parts (see general arrangement on Plate 114):

First. A central pumping station.

Second. Pipe lines and hydraulic monitors.

Third. Dredging pumps.

CENTRAL PUMPING STATION.

The pumping station is located centrally with reference to the area to be excavated and on the bank of the Rio Grande west of the canal. The building is a light-framed structure divided longitudinally into a pump room 50 by 100 feet and a boiler room 40 by 100 feet. There are four Worthington horizontal, direct-acting, triple-expansion pumping engines with 24-inch stroke, 24½-inch water cylinders, and 19, 30, and 50 inch steam cylinders. Each pump is provided with a surface condenser and a direct-acting, single cylinder 12 by 20 by 24 inch vacuum pump. The pumps discharge into a common delivery pipe and are equipped with the necessary check and gate valves.

There are four Babcock and Wilcox standard water-tube boilers arranged in batteries of two each. Each boiler has 4,500 square feet of heating surface and are designed for a working pressure of 150 pounds without superheat. They have steel casing and are arranged for using either oil or coal as fuel. A steel smokestack 9 feet 6 inches in diameter and 150 feet high is located between the batteries and connected to the same by steel breeching. Fuel oil will be stored in two steel tanks, of 2,000 barrels capacity each, located on a hill in rear of the station, and will be fed by gravity to the oil burners.

Each of the four units is guaranteed to supply 7,500 gallons of water per minute at 150 pounds pressure, with a boiler efficiency of 95 foot-pounds per B. t. u.

PIPE LINES AND MONITORS.

The supply main from the pumping station is 3,600 feet long, made up of 2,000 feet of 40-inch and 800 feet of 32-inch lock-bar pipe, and 800 feet of 24-inch spiral riveted pipe. The pipes are made of Nos. 6, 8, and 10 U. S. standard gauge plates, respectively, in lengths of 30 feet. The main contains five air valves and twelve tees suitably located for connecting the branch lines leading to the monitors; the branch lines are 16-inch spiral riveted pipe, laid in groups of three so that two giants may continue work while the third line is being changed. The hydraulic giants or monitors are fitted with special deflecting nozzles, and are of the improved type manufactured by the Joshua Hendy Iron Works. The main will first be laid north from the station as indicated by the full line on Plate 114; after completing the work between the locks and pumping station it will be relaid to the south as shown by broken line.

DREDGING PUMPS.

There are three 18-inch single-suction, centrifugal dredging pumps, direct-connected to a 655-horsepower induction motor. The impellers are made of manganese steel with five blades, and are designed to lift 10,000 gallons per minute of salt water containing 10 per cent of solid matter, and to discharge the same against a head of 60 feet.

The motors are Westinghouse standard, designed for 3-phase alternating current at 2,080 volts and 25 cycles. Each motor is provided with a starter consisting of seven oil-immersed switches that first connect the motor to a reduced voltage, which gradually increases. Each pump, together with its motor, switchboard, and priming pump, is mounted on a reinforced concrete barge, shown in detail on Plate 115.

METHOD OF OPERATION.

A portion of the area to be excavated was originally occupied by the bed of the Rio Grande. The river has been diverted and a dike will be built across the south end to prevent the tide water from flowing up the old bed. Upon the completion of the dike the water remaining in the inclosure will be pumped out until just enough remains to float the barges in the lowest places. The giants will first be operated in the immediate vicinity of the barges so as to lower them to bed rock, thus forming a sump for the suctions of each dredging pump. The regular operation of undercutting and washing the material to the dredging pumps by means of the monitors will then begin, the cutting being extended until there is insufficient slope to sluice the material to the dredging units; the water will then be allowed to rise high enough to float the barges to new positions.

The monitors will have a pressure of 130 pounds per square inch at the nozzle, and there will be three excavating units, consisting of a dredging pump supplied by either one or two monitors as may be found most advantageous for handling the material. The dredging pumps will discharge into flumes and by means of the latter the material will be distributed over the adjacent swamp lands. About 1,000,000 cubic yards will be pumped into the west dam at Miraflores to form the impervious core, and the elevation is such that a booster pump will be required, which has already been installed. If found advisable after the completion of the dam, this pump may be placed on a barge to form a fourth unit for the channel work.

Sand for Concrete.

Sand for the lock construction is obtained from a bay formed by Point Chame, which is about 20 miles up the coast from Balboa. It is dredged from the bay by a French self-propelling ladder dredge, loaded into barges of 500 cubic yards capacity, and towed to Balboa, where it is transferred from the barges to storage bins by means of rapid unloading cranes and runs by gravity from the bins into dump cars for transportation to the storage trestles at the lock sites.

There are three unloading cranes employed in transferring the sand from barges to bins. They were furnished by the Cleveland Crane and Engineering Company and have a single cantilever 33 feet long projecting beyond the face of the dock, as shown on Plate 116. Each crane is provided with a 3-cubic-yard clam-shell bucket and has a hoisting speed of 300 feet per minute. The hoisting, trolleying, and bridging movements are performed by 100-horsepower, 20-horsepower, and 15-horsepower 550-volt direct current motors, respectively. Air-controlled brakes are used on the hoist, the air being furnished by a small railway-type air compressor on each crane.

TABLE 14.—*Sand supplied during the fiscal year.*

Month.	Cubic yards of sand supplied.			
	Atlantic division.	Pacific division.	Other departments.	Total.
1909.				
July				
August				
September	4,380	1,320	24	5,724
October	8,100	3,911	485	12,496
November	10,520	4,368	717	15,605
December	11,965	6,122	755	18,842
1910.				
January	14,155	9,393	65	22,613
February	8,595	18,585	220	27,400
March	4,585	25,503	658	30,746
April	7,493	20,949	1,434	29,876
May	14,111	19,192	1,963	35,266
June	17,844	17,526	922	36,292
Total	101,748	126,869	7,243	235,860

BALBOA SHOPS AND SHIPWAYS.

Necessary running repairs have been made to the plant and floating equipment, and the following erection work has been done at the shops and shipways during the year:

NEW PLANT ERECTED.

Drill barge.—The erection of the drill barge *Teredo* was completed in February, 1910, and after several days of trial and adjustment of machinery began active operations in the following months.

Dump scows.—Four new dump scows were received knocked down, and were reassembled and placed in commission prior to March, 1910.

Floating repair shop.—An old French hull was repaired and equipped with the various machine tools required for making minor repairs to the floating equipment while in its working position.

Crane boat.—This was placed in commission on January 3, 1910, and consists of a repaired French hull fitted with a crane and pneumatic tools for repairing floating equipment.

Coal lighters.—Two Panama Railroad barges were converted into coal lighters and are used for supplying fuel to the floating plant.

Floating pile driver.—A French hull was repaired and equipped as a floating pile driver. It was completed ready for service in May, 1910.

Channel buoys.—Four buoys were made and used for marking the channel from deep water to the Panama Railroad docks.

RENEWALS AND REPAIRS.

Dredge Culebra.—In addition to running repairs, the hull of the *Culebra* was cleaned and painted, tail shaft and propellers renewed, and the machinery given a general overhauling.

Dredge Sandpiper.—The machinery was dismantled and hull cut into sections of suitable size for shipment by rail to the Atlantic division.

Dredge Gopher.—The *Gopher* was given a general overhauling before being sent to Chame in the sand service. The work performed included cleaning and painting the hull, replacing some of the plates, and installing a new port boiler.

Dredges Mole, Badger, and Marmot.—The work on these dredges was chiefly running repairs; new boilers were placed on the *Mole.*

Miscellaneous.—All tugs, scows, barges, and small boats were kept in running order, and numerous repairs of a minor nature were made for the Panama Railroad, vessels making port at Balboa, and for other departments and divisions.

Third District.

MUNICIPAL AND SANITARY WORK.

[H. O. Cole, assistant engineer.]

Municipal Engineering.

This department operates and maintains certain permanent plants and makes all municipal improvements within the confines of the division, including the city of Panama.

The permanent plants are the Ancon and Cocoli pumping and filtration stations and the Rio Grande Reservoir.

ANCON PUMPING AND FILTRATION STATION.

This station consists of two 10 by 6 by 10 inch duplex and two 12 by 8.5 by 12 inch duplex pumps, which are supplied with steam by two 125-horsepower oil-burning, return tubular boilers. The filters have a capacity of 1,500,000 gallons in twenty-four hours and have been in continuous operation throughout the year. The plant was maintained in good running order, and 143 linear feet of 16-inch suction pipe laid to replace a smaller pipe.

Details of work and cost at the Ancon station are shown in Table 15.

Table 15.—*Details of work and cost, Ancon pumping and filtration station.*

Month.	Water pumped.	Cost of pumping.					Water filtered.	Cost of filtering.			
		Labor.	Material.	Steam revenue.	Net total.	Per 1,000 gallons.		Labor.	Material.	Total.	Per 1,000 gallons.
1909.	*Gallons.*						*Gallons.*				
July	8,060,000	$421.15	$857.29	$428.20	$850.24	$0.1055	37,024,000	$39.25	$93.00	$132.25	$0.0036
August	7,642,000	295.93	467.50	103.20	660.23	.0864	36,465,000	50.13	78.00	128.13	.0035
September	8,100,000	350.01	437.34	103.20	684.15	.0845	37,109,000	68.74	143.96	212.70	.0057
October	8,915,000	268.84	466.13	103.20	631.77	.0709	39,130,000	55.72	237.20	292.92	.0075
November	8,268,000	245.03	460.06	103.20	601.89	.0728	37,266,000	41.25	196.72	237.97	.0064
December	9,299,000	302.37	522.46	103.20	721.63	.0775	38,973,000	50.49	168.54	219.03	.0056
1910.											
January	11,070,000	344.76	406.93	....	751.69	.0679	41,199,388	41.25	146.60	187.85	.0046
February	9,221,000	186.14	364.02	....	550.16	.0597	36,592,325	45.68	89.30	134.98	.0037
March	10,194,000	208.78	410.50	....	619.28	.0607	41,180,000	44.77	38.50	83.27	.0020
April	9,993,000	223.99	361.04	....	585.03	.0586	41,575,000	49.04	53.38	102.42	.0025
May	10,357,000	189.10	372.10	....	561.20	.0542	43,555,185	40.29	94.04	134.33	.0031
June	11,680,000	190.18	393.10	....	583.28	.0499	43,398,992	41.70	139.36	181.06	.0042
Total.	112,799,000	3,226.28	5,518.47	944.20	7,800.55	.0691	473,467,890	568.31	1,478.60	2,046.91	.0043

COCOLI PUMPING AND FILTRATION STATION.

Prior to March 31, 1910, the Rio Grande Reservoir supplied water for Culebra and all points south, including the city of Panama, for both domestic and construction purposes, through a 16-inch cast-iron main terminating at the Ancon pumping station, 9.8 miles from the reservoir. The consumption gradually increased, resulting finally in a material reduction of pressure and supply at the south end. Various plans were considered for overcoming the difficulty, and it was determined to secure additional water from the lake formed by the partial construction of the west dam at Miraflores, known at present as Cocoli Lake, though it will eventually form a portion of the Miraflores Lake. The general arrangement of the plant is shown on Plate 117, and it may be divided into the following units: Pumps, treating and settling tanks, and filters.

Pumps.—There are two 10-inch, 2-stage, centrifugal pumps, direct connected to 80-horsepower, 3-phase, 25-cycle, 2,080-volt induction motors.

Treating and settling tanks.—This unit consists of two 2,100-gallon tanks for storing and supplying the sulphate of aluminum solution, one 7,000-gallon coagulant or mixing tank, and two 50,000-gallon settling tanks.

Filters.—There are two 8 by 20 foot mechanical filters located in the basement of the Miraflores power house.

Operation.—One of the pumps takes water from the lake through 1,600 feet of 16-inch suction pipe and discharges into the 7,000-gallon mixing tank. After being thoroughly mixed with the solution the water passes by gravity into the settling tanks near their bottoms. The second pump takes water from near the top of the settling tanks and forces it to the filters and through them into the 16-inch main at a pressure of about 70 pounds, there being 5 pounds loss in passing through the filters.

There is also a 60,000-gallon tank located on high ground near the power house, which is supplied with filtered water that is used for washing the filters, and may supply the power-house boilers in an emergency.

Details of work and cost at the Cocoli station are shown in Table 16.

TABLE 16.—*Details of work and cost, Cocoli pumping and filtration station.*

Month.	Water pumped.	Cost of pumping.				Water filtered.	Cost of filtering.			
		Labor.	Material.	Total.	Per 1,000 gallons.		Labor.	Material.	Total.	Per 1,000 gallons.
1909.	*Gallons.*					*Gallons.*				
July										
August										
September										
October										
November										
December										
1910.										
January										
February										
March										
April	13,955,866	$179.78	$657.82	$837.60	$0.0600	13,955,866	$45.51	$50 00	$95.51	$0.0078
May	11,825,000	320.14	252.47	572.61	.0485	11,825,000	49.90	74.00	174.78	.0106
June	13.823,000	170.35	1,121.08	1,291.43	.0934	13,823,000	57.00	109.50	166.50	.0120
Total	39,603,866	670.27	2,031.37	2,701.64	.0682	39,603,866	152.41	234.38	386.79	.0098

Detailed statement showing cost of construction is given in Table 17.

TABLE 17.—*Cost of construction, Cocoli pumping and filtration station.*

Item.	Labor.	Material.	Total.
16-inch suction line	$1,584.03	$3,567.53	$5,151.56
Erecting pumps and house	1,423.96	5,795.62	7,219.58
Constructing tanks and piping	1,780.25	3,014.83	4,795.08
10-inch discharge line	1,459.64	2,807.09	4,266.73
Erecting pressure filter tanks	1,794.00	9,005.19	10,799.19
Erecting filter washing tank	1,343.69	748.56	2,092.25
Total	9,385.57	24,938.82	34,324.39

RIO GRANDE QUARRY.

This quarry was abandoned in February, 1910, when the Ancon quarry began operation. Prior to that time it furnished broken stone for ballast, highway construction, and the temporary concrete mixing plant at Pedro Miguel.

TABLE 18.—*Details of work and cost, Rio Grande quarry.*

Month.	Output.	Total cost.	Cost per cubic yard.
1909.	*Cubic yards.*		
July	4,375	$5,474.41	$1.25
August	2,654	3,662.05	1.38
September	4,375	5,095.00	1.17
October	6,553	8,387.65	1.28
November	7,505	11,179.48	1.49
December	13,754	18,418.08	1.34
1910.			
January	19,488	23,891.39	1.23
February	7,288	8,196.24	1.12
March			
April			
May			
June			
Total	65,992	84,304.36	1.32

Crusher closed down February 12, 1910.

RIO GRANDE RESERVOIR.

This reservoir supplies Culebra and all points south, including the city of Panama. It has been maintained at a total cost of $6,709.89 for the year and furnished 1,259,771,000 gallons of water, of which the city of Panama used 360,815,790 gallons. The 5¼-inch throat in the Venturi meter was replaced by an 8-inch throat.

The following data may be of interest:

Drainage area	square miles	3.15
Maximum lake area	acres	72.77
Elevation of spillway, with flash boards	feet	238.17
Maximum depth of water	do	52.67
Total capacity	gallons	490,667,000
Storage at lowest elevation, 1909–10	do	245,567,000
Average daily consumption, 1909–10	do	3,556,003
Average daily consumption, city of Panama, 1909–10	do	988,536

A detailed statement of the water consumption by districts is given in Table 19.

PANAMA IMPROVEMENTS.

All municipal and sanitary improvements in the city of Panama are made by the commission and the cost repaid through the collection of water taxes, as provided in Article VII of the treaty between the United States and the Republic of Panama. In the past year the streets have been graded and macadamized, and sewers, water mains, and concrete curbs and gutters placed in the following districts of the city: Guachapali, Santa Cruz, Cocoa Grove, Ancon boulevard and Avenue B intersecting streets. The water and sewer lines were also extended along the Calidonia road a distance of 2,300 feet to the new orphan asylum.

The districts improved are shown on Plate 118 and the amount and cost of the work are detailed in Table 20.

TABLE 19.—*Consumption of water by districts, 1909–10.*

Month.	Panama.	Ancon high service.	Tivoli section.	Balboa (6-inch main).	Cucaracha pump.	Pedro Miguel, Paraiso, Comacho, Miraflores, Corozal, and Balboa 10-inch main.[a]	Source of supply.		
							Rio Grande reservoir.	Cocoli Lake.	Total.
	Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
1909.									
July	28,970,000	8,060,000	1,892,500	8,989,400	17,439,518	31,730,582	97,082,000		97,082,000
August	28,770,000	7,642,000	1,840,200	8,616,100	20,772,510	29,556,190	97,197,000		97,197,000
September	29,009,000	8,108,000	1,942,200	8,269,400	19,253,738	27,686,662	94,269,000		94,269,000
October	30,215,000	9,103,000	1,539,100	8,909,200	22,408,356	32,258,344	104,433,000		104,433,000
November	28,998,000	8,300,000	1,950,200	6,702,500	19,494,512	39,750,788	105,196,000		105,196,000
December	29,674,000	8,996,000	1,247,400	6,048,700	20,679,084	45,248,816	111,894,000		111,894,000
1910.									
January	30,129,388	11,287,000	1,249,400	5,297,400	19,220,762	46,289,050	113,473,000		113,473,000
February	27,371,225	9,182,000	2,276,500	5,565,700	16,423,264	42,020,311	102,839,000		102,839,000
March	31,180,000	10,341,000	1,905,100	4,424,400	18,322,660	47,558,840	113,732,000		113,732,000
April	31,582,000	10,062,000	1,760,300	6,093,700	19,416,200	48,427,800	104,875,000	12,467,000	117,342,000
May	33,198,000	10,337,000	1,760,300	5,258,200	20,335,681	49,661,634	108,699,000	11,852,000	120,551,000
June	31,718,992	11,464,000	1,760,300	4,491,200	20,738,052	49,769,456	106,082,000	13,860,000	119,942,000
Total	360,815,790	112,882,000	21,123,500	78,665,900	234,504,337	489,958,473	1,259,771,000	38,179,000	1,297,950,000

[a] Approximate.

NOTE.—The consumption given for Pedro Miguel, Paraiso, Comacho, Miraflores, Corozal, and the new 10-iuch Balboa main is the difference between the total consumption of the various other districts (which are metered) and the total supply.

TABLE 20.—*New street improvements in the city of Panama—Work performed by the Pacific division, Isthmian Canal Commission, during fiscal year ending June 30, 1910.*

Name of street.	Paving and curbing.			Sewer mains and laterals.					Water mains and laterals.					Total cost of streets.	Total cost of districts.
	Length of street.	Width of street.	Cost.	Mains.		Laterals.		Cost.	Mains.		Laterals.		Cost.		
				Length.	Diameter.	Length.	Diameter.		Length.	Diameter.	Length.	Diameter.			
COCOA GROVE.	*Feet.*	*Feet.*		*Lin. ft.*	*In.*	*Lin. ft.*	*In.*		*Lin. ft.*	*In.*	*Lin. ft.*	*In.*			
West Seventeenth street	410	18	$1,398.28	...	...	110	6	$107.35	368	4	139	$\frac{3}{4}$	$408.99	$1,914.62	
West Eighteenth street	840	18	2,334.16	600	8	226	6	574.21	578	4	330	$\frac{3}{4}$	665.81	3,574.18	
West Nineteenth street	780	18	2,200.22	...	...	90	6	64.53	480	4	243	$\frac{3}{4}$	618.37	2,883.12	
West Twentieth street	830	18	2,867.07	851	8	248	6	1,006.08	838	...	316	$\frac{3}{4}$	769.64	4,642.79	
Sur avenue	215	16	615.35	232	8	48	6	206.65	230	4	...	$\frac{3}{4}$	216.04	1,038.04	
San Vicenti	845	18	2,592.73	...	...	150	6	127.38	...	...	157	$\frac{3}{4}$	239.87	2,959.98	17,012.73
GUACHAPALI.															
Thirty-first street	522	24	*a* 1,752.43	547 247	8 10	184	6	1.526.27	547	6	276	$\frac{3}{4}$	809.99	4,088.69	
Thirty-second street	582	24	*a* 2,236.33	612	8	188	6	806.16	1,019	6	396	$\frac{3}{4}$	1,090.24	4,132.73	
Thirty-third street	572	24	3,094.37	593	8	188	6	752.97	617	6	416	$\frac{3}{4}$	793.33	4,640.67	
Thirty-fourth street	570	24	*a* 172.52	...	...	...	...	...	...	...	...	...	...	172.52	
Thirty-fifth street	561	24	2,167.66	591	10	176	6	1,416.15	714	6	335	$\frac{3}{4}$	886.92	4,470.73	
Thirty-sixth street	360	24	1,771.62	336	8	96	6	924.93	399	6	206	$\frac{3}{4}$	595.37	3,291.92	
Istmo street	1,644 125	24 18	8,802.81	1,448 183	8 10	232	6	2,288.41	1,643	8	456	$\frac{3}{4}$	2,515.50	13,606.72	
Republica street	1,040	24	*b* 4,447.22	1,035	10	316	6	1,943.56	1,031	6	708	$\frac{3}{4}$	1,446.86	7,837.64	
Ossa street	580	24	1,911.42	564	8	110	6	777.73	596	6	211	$\frac{3}{4}$	727.36	3,416.51	
Escobar street	580	24	*a* 2,090.67	592	10 30	192	6	769.44 942.77	604	6	350	$\frac{3}{4}$	728.37	4,531.25	
Concordia street	355	24	*b* 1,114.33	357	8	120	6	388.86	377	6	328	$\frac{3}{4}$	472.16	1,975.35	
Herobar street	390	24	1,771.42	430	10	150	6	473.35	429	6	330	$\frac{3}{4}$	505.66	2,750.43	
Mueller place	290	24	793.08	...	...	...	...	...	313	8	...	$\frac{3}{4}$	453.53	1,246.61	56,161.77
AVENUE B.															
East Twentieth street	380	16	*b* 745.21	340	8	112	6	359.06	330	6	153	$\frac{3}{4}$	364.51	1,468.78	
East Twenty-first street	345	15	*b* 921.56	302	8	104	6	311.52	289	6	104	$\frac{3}{4}$	332.85	1,565.93	
East Twenty-second street	287	16	*b* 856.09	250	8	91	6	332.90	208	6	132	$\frac{3}{4}$	275.03	1,464.02	

a Indicates paving and curbing incompleted.

b Indicates paving incompleted.

TABLE 20.—*New street improvements in the city of Panama—Work performed by the Pacific division, Isthmian Canal Commission, during fiscal year ending June 30, 1910*—Continued.

Name of street.	Paving and curbing.			Sewer mains and laterals.					Water mains and laterals.					Total cost of streets.	Total cost of districts.
	Length of street.	Width of street.	Cost.	Mains.		Laterals.		Cost.	Mains.		Laterals.		Cost.		
				Length.	Diameter.	Length.	Diameter.		Length.	Diameter.	Length.	Diameter.			
AVENUE B—Continued.	*Feet.*	*Feet.*		*Lin. ft.*	*In.*	*Lin. ft.*	*In.*		*Lin. ft.*	*In.*	*Lin. ft.*	*In.*			
East Twenty-third street	220	15	a $723.90	175	8	60	6	$271.13	161	6	59	$\frac{3}{4}$	$240.75	$1,235.78	
Obarrio place	470	18	a 1,466.28	420	8	190	6	471.65	420	6	238	$\frac{3}{4}$	495.34	2,433.27	
Lyons street	500	18	(b)	450	8	108	6	399.14	439	6	102	$\frac{3}{4}$	385.96	785.10	$8,952.88
SANTA CRUZ.															
Thirty-seventh street	320	18	b 1,198.08	342	8	110	6	444.41	360	6	177	$\frac{3}{4}$	482.39	2,124.88	
Thirty-eighth street	675	18	b 1,237.27	1,256	8	230	6	984.95	715	6	437	$\frac{3}{4}$	889.70	3,111.92	
Thirty-ninth street	365	18	b 1,063.21	400	8	120	6	454.26	402	6	243	$\frac{3}{4}$	580.94	2,098.41	
Fortieth street	470	18	b 1,270.96	487	8	140	6	492.98	497	6	342	$\frac{3}{4}$	551.10	2,315.04	
Independencia street	738	18	b 2,400.91	723	8	132	6	1,027.73	721	6	154	$\frac{3}{4}$	798.91	4,227.55	
Constitucion street	792	18	b 2,264.90	802	8	142	6	1,103.36	802	6	421	$\frac{3}{4}$	883.07	4,251.33	
America street	552	18	b 1,363.58	710	8	152	6	893.35	752	6	406	$\frac{3}{4}$	945.77	3,202.70	
Perigault street	350	18	b 606.61	367	8	120	6	328.01	375	6	232	$\frac{3}{4}$	424.27	1,358.89	
Caledonia street	800	....	b 112.52	793	8	248	6	1,180.09	743	6	324	$\frac{3}{4}$	1,086.85	2,379.46	25,070.18
Caledonia road extended, etc.	....	....	4,010.28	2,198	8	558	6	2,114.48	2,325	6	1,322	$\frac{3}{4}$	2,263.15	8,387.91	8,387.91
DISTRICT 1.															
Ancon Boulevard	960	20	2,912.53	828 362	8 18	449	6	1,332.87 360.15	1,182	6	529	$\frac{3}{4}$	1,289.95	5,895.50	
Jose Higinio	315	16	b 732.96	306	8	179	6	423.96	13	4	148	$\frac{3}{4}$	120.58	1,277.50	7,173.00
Total division cost	....	....	68,020.54	....	....	....	....	28,382.80	....	....	....	....	26,355.13	122,758.47	122,758.47
Administration and general expenses	....	....	6,595.83	....	....	....	....	2,758.26	....	....	....	....	2,638.33	....	11,992.42
Total cost	....	....	74,616.37	....	....	....	....	31,141.06	....	....	....	....	28,993.46	....	134,750.89

a Indicates paving completed. b Indicates paving and curbing incompleted.

NOTE.—Cost of sewer mains and laterals includes manholes; cost of water mains and laterals includes fire hydrants, etc.; cost of paving and curbing includes street grading, basket gutters, etc.

ZONE WATERWORKS.

The water mains were maintained and patrolled, numerous house connections and fire hydrants were installed, and the system was extended by laying 9,443 feet of 10-inch and 4,141 feet of 8-inch main between the Ancon pumping station and Balboa. A number of additional houses in Ancon hospital grounds were connected with the high-pressure service, and the location of about 3,790 feet of the 16-inch main was changed in the vicinity of Pedro Miguel and Corozal on account of changes in the relocation of the Panama Railroad. The cost of maintenance and repairs is given in Table 21.

TABLE 21.—*Maintenance and repairs, Zone waterworks.*

Description.	Labor.	Material.	Total.
Rio Grande Reservoir	$2,766.59	$453.86	$3,220.45
Rio Grande Reservoir (clearing slopes)	3,489.44		3,489.44
Pedro Miguel district	1,701.32		1,701.32
Miraflores district	566.72		566.72
Corozal district	402.51		402.51
Ancon district	1,213.69		1,213.69
Balboa district	117.55		117.55
East Balboa district	79.51		79.51
Total	10,337.33	453.86	10,791.19

NOTE.—The costs of maintaining the Ancon and Cocoli pumping and filtration plants are given elsewhere.

A detailed statement of the construction work performed during the year is given in Table 22.

TABLE 22.—*Statement of construction work performed on Zone waterworks during year ended June 30, 1910.*

Description.	Quantity.	Labor.	Material.	Total.	Unit cost.
PEDRO MIGUEL DISTRICT.					
Changing location of 16-inch main:					
Excavation	442 cubic yards	$764.98		$764.98	$1.73
Back fill	107 cubic yards	60.91		60.91	.57
Reclaiming and laying 16-inch cast-iron pipe.	833 linear feet	826.86		826.86	.99
Reclaiming and laying pipe	100 feet 4-inch 130 feet 3½-inch 174 feet 3-inch 20 feet 2-inch 190 feet 1½-inch 120 feet ¾-inch	62.55	$60.89	123.44	.18
Handling and distributing		268.82	10.11	278.93	
Miscellaneous		246.03	41.46	287.49	
Total		2,230.15	112.46	2,342.61	
Connecting Pacific and Central division standpipes:					
Excavation	111 cubic yards	121.78		121.78	1.09
Back fill	68 cubic yards	26.79		26.79	.39
Laying 10-inch cast-iron pipe		5.76	19.68	25.44	
Laying 6-inch cast-iron pipe	284 linear feet	51.49	95.11	146.60	.52
Handling and distributing		39.43	1.33	40.76	
Miscellaneous		123.22	6.28	129.50	
Total		368.47	122.40	490.87	
Miscellaneous connections		109.91	27.89	137.80	
Total, Pedro Miguel district		2,708.53	262.75	2,971.28	

TABLE 22.—*Statement of construction work performed on Zone waterworks during year ended June 30, 1910*—Continued.

Description.	Quantity.	Labor.	Material.	Total.	Unit cost.
MIRAFLORES DISTRICT.					
Changing location of 16-inch water main near bridge No. 62:					
Excavation	1,931 cubic yards	$1,275.45		$1,275.45	$0.66
Back fill	913 cubic yards	253.00		253.00	.27
Reclaiming and laying 16-inch pipe.	3,137 linear feet	1,163.77	$382.63	1,546.40	.49
Handling and distributing		615.91	59.71	675.62	
Total		3,308.13	442.34	3.750.47	
Connecting power house with 16-inch main:					
Excavation	142 cubic yards	120.31		120.31	.85
Back fill	142 cubic yards	59.42		59.42	.42
Laying 4-inch cast-iron pipe	1,885 linear feet	125.66	194.96	320.62	.18
Handling and distributing		37.91		37.91	
Miscellaneous		29.61		29.61	
Total		372.91	194.96	567.87	
Laying 10-inch cast-iron pipe at Cocoli shops:					
Excavation	12 cubic yards	18.20		18.20	1.51
Laying 10-inch cast-iron pipe	638 linear feet	159.07	580.07	739.14	1.15
Handling material		60.51		60.51	
Total		237.78	580.07	817.85	
Laying 6-inch wrought-iron pipe and erecting standpipe, Cocoli shops:					
Excavation	94 cubic yards	96.49		96.49	1.02
Back fill	94 cubic yards	29.57		29.57	.31
Laying 6-inch wrought-iron pipe	211 linear feet	33.98	105.50	139.48	.66
Erecting 6-inch standpipe		42.84		42.84	
Handling material		13.51		13.51	
Total		216.39	105.50	321.89	
Miscellaneous connections		75.78		75.78	
Total, Miraflores district		4,210.99	1,322.87	5,532.86	
COROZAL DISTRICT.					
Connecting recreation building, Corozal:					
Excavation	29 cubic yards	20.89		20.89	.72
Back fill	8 cubic yards	3.00		3.00	.37
Laying ¾-inch galvanized-iron pipe	44 linear feet	4.36	1.31	5.67	.13
Miscellaneous		1.82	3.89	5.71	
Total		30.07	5.20	35.27	
Miscellaneous connections		30.46	13.50	43.96	
Total, Corozal district		60.53	18.70	79.23	
ANCON DISTRICT.					
Ancon and Balboa water system:					
Excavation	2,663 cubic yards	1,910.97		1,910.97	.72
Back fill	1,981 cubic yards	832.97		832.97	.42
Laying 10-inch and 8-inch cast-iron pipe.	9,443 feet 10-inch and 4,141 feet 8-inch.	1,121.94	12,092.88	13,214.82	.97
Laying 16-inch pipe	143 linear feet	282.96	318.89	601.85	1.98
Handling material		840.00	309.99	1,149.99	
Miscellaneous		280.94	1.81	282.75	
Total		5,269.78	12,723.57	17,993.35	
Connecting up insane asylum buildings:					
Excavation	203 cubic yards	100.70		100.70	.49
Back filling	192 cubic yards	44.79		44.79	.23
Laying ¾-inch, 1-inch, and 1½-inch galvanized-iron pipes.	180 feet ¾-inch; 163 feet 1-inch; 492 feet 1½-inch	15.21	16.12	31.33	.04
Handling and distributing		12.08	9.04	21.12	
Miscellaneous		43.21		43.21	
Total		215.99	25.16	241.15	

TABLE 22.—*Statement of construction work performed on Zone waterworks during year ended June 30, 1910*—Continued.

Description.	Quantity.	Labor.	Material.	Total.	Unit cost.
ANCON DISTRICT—continued.					
Laying 4-inch line from hospital grounds to Ancon quarry:					
Excavation	225 cubic yards	$127.11		$127.11	$0.56
Back fill	116 cubic yards	40.05		40.05	.34
Laying 4-inch galvanized-iron pipe.	2,269 linear feet	63.15	$149.68	212.83	.09
Handling and distributing		44.92	22.11	67.03	
Total		275.23	171.79	447.02	
Changing 2-inch line, Ancon quarry:					
Excavation	43 cubic yards	23.62		23.62	.55
Back fill	42 cubic yards	11.63		11.63	.28
Laying 4-inch pipe	1,236 linear feet	34.08	2.82	36.90	.03
Handling and distributing		5.36	1.11	6.47	
Total		74.69	3.93	78.62	
Installing 3 fire hydrants		148.82	216.99	365.81	121.93
Changing supply line, Ancon laundry		37.28	32.94	70.22	
Connecting standpipes to fire service, Hotel Tivoli.		45.73	24.09	69.82	
Installing 16-inch valve		99.39	73.16	172.55	
Ancon Reservoir, terracing		101.73	2.50	104.23	
Changing houses to high-pressure service.		93.60	12.38	105.98	
Miscellaneous connections		174.08	104.52	278.60	
Total, Ancon district		6,536.32	13,391.03	19,927.35	
BALBOA DISTRICT.					
Installing 2 fire hydrants		124.35	114.79	239.14	119.57
Installing 8 by 8 foot French tank		93.93	8.61	102.54	
Miscellaneous connections		72.53	12.01	84.54	
Total, Balboa district		290.81	135.41	426.22	
MISCELLANEOUS.					
Installing regulating box, Rio Grande Reservoir.		111.59	19.94	131.53	
Installing 8-inch throat to Venturi meter, Rio Grande Reservoir.		59.02		59.02	
Palo Seco water system		109.16	141.88	251.04	
Grand total		14,086.95	15,292.58	29,379.53	

ZONE SEWERAGE SYSTEM.

The outfalls at Balboa and the Italian camp at Ancon were extended and the Ancon system was extended to include the new insane asylum and corral. A complete system of sewers for Palo Seco was begun but not completed in the year. Aside from the above all work consisted in making minor extensions and connections required by the erection of new buildings. Details are given in Table 23.

TABLE 23.—*Statement of work performed on sewers during fiscal year ended June 30, 1910.*

Description.	Quantity.	Labor.	Material.	Total.	Unit cost.
PEDRO MIGUEL DISTRICT.					
Connection to quartermaster's department storehouse.	319 feet 6-inch vitrified pipe.	$61.77	$44.78	$106.55	$0.33
Repairs to sewer		103.28		103.28	
Miscellaneous connections		21.05	5.02	26.07	
Total, Pedro Miguel district		186.10	49.80	235.90	
MIRAFLORES DISTRICT.					
Changing sewer location, Cocoli shops:					
Excavation	25 cubic yards	24.18		24.18	.97
Back fill	24 cubic yards	11.77		11.77	.49
Laying 8-inch vitrified pipe	150 lineal feet	4.75	28.90	33.65	.22
Handling material		13.59		13.59	
Total		54.29	28.90	83.19	
Miscellaneous connections		29.25	7.25	36.50	
Total, Miraflores district		83.54	36.15	119.69	
COROZAL DISTRICT.					
Connections to recreation building:					
Excavation	29 cubic yards	20.88		20.88	.74
Back fill	9 cubic yards	3.00		3.00	.33
Laying 6-inch vitrified pipe	213 lineal feet	13.46	21.30	34.76	.16
Miscellaneous		1.83	3.89	5.72	
Total		39.17	25.19	64.36	
Connections to commissary		22.31		22.31	
Lowering sewer near motor-car house		129.52		129.52	
Miscellaneous connections		8.44	14.06	22.50	
Total, Corozal district		199.44	39.25	238.69	
ANCON DISTRICT.					
Connections to new corral:					
Excavation	162 cubic yards	69.44		69.44	.43
Back fill	90 cubic yards	27.82		27.82	.31
Laying 8-inch vitrified pipe	325 lineal feet	55.30	77.14	132.44	.41
Installing 4 manholes		68.08		68.08	17.02
Handling material		4.82	5.09	9.91	
Miscellaneous		1.19	10.22	11.41	
Total		226.65	92.45	319.10	
Connections to insane asylum building:					
Excavation	203 cubic yards	100.70		100.70	.50
Back fill	193 cubic yards	44.50		44.50	.23
Laying 6-inch and 8-inch vitrified pipe.	500 feet 8-inch and 975 feet 6-inch.	124.41	132.69	257.10	.17
Handling and distributing		12.09	9.05	21.14	
Miscellaneous		43.21		43.21	
Total		324.91	141.74	466.65	
Installing 6-inch sewer, Ancon Hospital.		83.22		83.22	
Miscellaneous connections		154.45	61.60	216.05	
Total, Ancon district		789.23	295.79	1,085.02	
BALBOA DISTRICT.					
Repairing and laying sewer outfall:					
Excavation	70 cubic yards	42.24		42.24	.60
Back fill	46 cubic yards	25.13		25.13	.55
Laying 6-inch sewer	176 lineal feet	12.59	41.54	54.13	.31
Handling and distributing		7.43		7.43	
Total		87.39	41.54	128.93	
Miscellaneous connections		220.65	120.14	340.79	
Total, Balboa district		308.04	161.68	469.72	
Connections for Panama R. R. Co		75.67	23.31	98.98	
Repairs to outfall, Cocoa Grove district, Panama.		268.18	176.10	444.28	
Palo Seco sewer system		101.54	206.81	308.35	
Grand total		2,011.74	988.89	3,000.63	

TABLE 23.—*Statement of work performed on sewers during fiscal year ended June 30, 1910*—Continued.

Zone sewer maintenance.

Location.	Labor.	Material.	Total.
Pedro Miguel district	$548.20		$548.20
Miraflores district	7.62		7.62
Corozal district	18.82		18.82
Ancon district	71.16		71.16
Balboa district	75.43		75.43
East Balboa district	27.63		27.63
Grand total	748.86		748.86

ZONE ROADS.

About 9,020 linear feet of the road from Corosal to Pedro Miguel (started during the previous year) were completed and a portion of the road connecting Corozal and Camp Diablo was changed during the year. Extensive repairs were made to the Balboa and Sabanas roads and to the Loseria and Tomba Muerta trails. Roads were extended in the several towns as required by the erection of new buildings, and all roads previously constructed were maintained in good condition. The cost of maintenance and repairs is given in Table 24.

TABLE 24.—*Maintenance and repairs, Canal Zone roadways.*

Location.	Length.	Labor.	Material.	Total.
	Feet.			
Pedro Miguel district		$825.93		$825.93
Corozal district		274.48		274.48
Ancon district		306.98		306.98
Balboa district		90.03		90.03
East Balboa district		126.19		126.19
Ancon Hospital roads, remacadamizing	7,870	2,725.60	$3,351.64	6,077.24
Sabanas road		138.54	183.73	322.27
Corozal-Diablo road, repairing		507.34	30.68	538.02
Corozal cinder paths, repairing	1,200	93.11		93.11
Cinder running track, Ancon Park		72.63	28.37	101.00
Balboa road, resurfacing	3,719	953.74	2,314.33	3,268.07
Total		6,114.57	5,908.75	12,023.32

A detailed statement of new roads constructed is shown in Table 25.

TABLE 25.—*Work performed on Canal Zone roads in the Pacific division, third district, during fiscal year ended June 30, 1910.*

Location.	Length.	Width.		Division cost.			
		Road-bed.	Maca-dam.	Labor.	Material.	Total.	Cost per linear foot.
	Feet.	*Feet.*	*Feet.*				
Corozal-Panama road [a]	17,100	22	16	$1,523.40	$698.76	$2,222.16	$0.13
Corozal-Pedro Miguel road [a]	9,020	22	16	733.39	1,192.07	1,925.46	.21
New road, Pedro Miguel, due to change in Panama R. R.	496	18	15	927.69	527.49	1,455.18	2.93
Cinder walks, Corozal	400	5		167.35	28.87	196.22	
Road and ford at Pedro Miguel (convict labor)	700			34.27	25.82	60.09	
Balboa road to docks (completed in fiscal year 1910)				7.05		7.05	
Quartermaster's department storehouse road, Corozal	427			244.50	106.03	350.53	.82
Tomba Muerta road (convict labor)	1,500	12		1.46	4.45	5.91	
Widening road 6 inches near new market, Ancon	100	6		113.49	90.62	204.11	
Changing road crossing near commissary, East Balboa	[b] 282			96.74	52.20	148.94	
Ancon corral roads				27.04		27.04	
Cement sidewalks and gutters, Ancon Hospital grounds	2,408			1,316.33	701.46	2,017.79	.84
Total				5,192.71	3,427.77	8,620.48	

[a] These roads were reported in the annual report for the year ended June 30, 1909. The costs here given are for macadamizing and finishing.
[b] Square yards.

MISCELLANEOUS.

Reenforced concrete reservoirs of 10,000 and 100,000 gallons capacity were constructed for the Palo Seco leper asylum and the Culebra Island quarantine station, respectively; the latter is located on Naos Island. (See Pls. 53 and 119.) Two thousand four hundred linear feet of concrete sidewalk with curb and gutter were laid in Ancon Hospital grounds, and various concrete and cinder walks were built throughout the district. Details of construction and cost of Palo Seco and Naos Island reservoirs are shown in Tables 26 and 27, respectively. Details of miscellaneous work performed during the year are given in Table 28.

TABLE 26.—*Cost of construction, Palo Seco reenforced concrete reservoir (10,000 gallons capacity).*

Class of work.	Quantity.	Labor.	Material.	Total.	Unit cost.
Excavation	53 cubic yards	$51.52		$51.52	$0.97
Concrete, mixing and placing	18 cubic yards	113.05	$259.45	372.50	20.70
Reenforcement	do		20.02	20.02	1.11
Forms, building and setting		184.78	29.66	214.44	
Transportation		84.94	5.38	90.32	
Miscellaneous			25.54	25.54	
Total		434.29	340.05	774.34	

NOTE.—Material and water for concrete carried from beach uphill to site, 800 feet.

TABLE 27.—*Cost of construction of Naos Island reenforced concrete reservoir (100,000 gallons capacity).*

Class of work.	Quantity.	Labor.	Material.	Total.	Unit cost.
Clearing and grubbing		$131.36		$131.36	
Excavation (clay and bowlders)	305 cubic yards	409.80		409.80	$1.35
Concrete	192 cubic yards	591.89		1,969.27	10.26
Cement	225 barrels		$446.95		
Gathering sand from beach	80 cubic yards		160.38		
Gathering rock from bar	150 cubic yards		770.05		
Reenforcement	192 cubic yards	120.00	215.82	335.82	1.75
Forms, building and setting		351.74	230.79	582.53	3.03
Laying 3½-inch galvanized-iron pipe	400 lineal feet	186.00	125.21	311.21	.778
Transportation		459.68	85.59	545.27	
Building incline		125.29		125.29	
Miscellaneous		333.49	320.37	653.86	
Total		2,709.25	2,355.16	5,064.41	

TABLE 28.—*Miscellaneous work performed in year ended June 30, 1910.*

Description.	Labor.	Material.	Total.
Installing boiler in laundry, Ancon	$367.20	$121.35	$488.55
Laying cement floor in shed, Ancon laundry	94.58	16.60	111.18
Replacing bumpers, Culebra Island pier	496.01	107.39	603.40
Replacing hoops on tanks, Culebra Island	94.95		94.95
Building tennis court, Corozal	127.73	75.94	203.67
Installing steam trap, etc., East Balboa Hotel	14.68	13.19	27.87
Washing boiler, East Balboa Hotel (monthly)	30.33		30.33
Washing boiler, Tivoli Hotel (monthly)	24.24		24.24
Clearing native village, Pedro Miguel	10.45		10.45
General surveys	738.81		738.81
Total	1,998.98	334.47	2,333.45

SANITARY WORK.

This work included digging and cleaning ditches, laying concrete and tile drains, filling swamp land, and other work of similar nature, by the request of and in accordance with plans furnished by the sanitary department. The work executed is shown in detail in Table 29.

TABLE 29.—*Statement of sanitary work performed during the fiscal year ended June 30, 1910.*

Class of work and location.	Quantity.	Division cost.			Unit cost.
		Labor.	Material.	Total.	
Cleaning earth drains:	*Linear feet.*				
Pedro Miguel	85,558	$4,056.81		$4,056.81	$0.447
Miraflores	37,562	1,714.95		1,714.95	.046
Corozal	154,589	2,252.22		2,252.22	.015
Ancon	125,728	1,888.39		1,888.39	.015
East Balboa	50,456	532.28		532.28	.011
Balboa	120,049	694.29		694.29	.006
Total	573,942	11,138.94		11,138.94	.019
Excavating new earth drains:	*Cubic yards.*				
Pedro Miguel	923	952.63		952.63	1.03
Miraflores	459	327.34		327.34	.71
Corozal	189	197.88		197.88	1.05
Ancon	507	354.27		354.27	.70
East Balboa	231	148.21		148.21	.64
Balboa	352	203.62		203.62	.58
Total	2,661	2,183.95		2,183.95	.82

TABLE 29.—*Statement of sanitary work performed during the fiscal year ended June 30, 1910*—Continued.

Class of work and location.	Quantity.	Division cost.			Unit cost.
		Labor.	Material.	Total.	
Sweeping cement drains:	*Linear feet.*				
Ancon	542,516	$438.52	....	$438.52	$0.0008
East Balboa	65,800	34.23	....	34.23	.0005
Balboa	223,537	238.12	....	238.12	.0012
Total	871,888	710.87	....	710.87	.0008
Filling swamps and holes:	*Cubic yards.*				
Pedro Miguel	59	39.12	....	39.12	.66
Miraflores	43	32.43	....	32.43	.75
Ancon	227	154.19	....	154.19	.68
East Balboa	296	202.79	....	202.79	.69
Balboa	64	34.49	....	34.49	.54
Total	689	463.02	....	463.02	.67
Constructing cement drains:	*Linear feet.*				
Pedro Miguel	540	703.70	$237.48	941.18	1.74
Ancon	4,404	1,958.77	586.11	2,544.88	.58
Balboa	4,756	1,990.74	620.40	2,611.14	.55
Total	9,700	4,653.21	1,443.99	6,097.20	.63
Laying tile drains:	*Linear feet.*				
Corozal	371	49.03	33.23	82.26	.22
Ancon	2,436	619.17	94.11	713.28	.29
Balboa	1,031	486.48	160.35	646.73	.63
Total	3,838	1,154.58	287.69	1,442.27	.38
Miscellaneous:					
Draining swamp, Balboa	....	67.01	7.33	74.34	....
Cleaning and repairing tile drains	....	104.91	2.11	107.02	....
Repairing cement drains	....	56.23	....	56.23	....
Total	....	228.15	9.44	237.59	....

RECAPITULATION.

Item.	Labor.	Material.	Total.
Cleaning earth drains	$11,138.94	....	$11,138.94
Excavating new earth drains	2,183.95	....	2,183.95
Sweeping cement drains	710.87	....	710.87
Filling swamps and holes	463.02	....	463.02
Constructing cement drains	4,653.21	$1,443.99	6,097.20
Laying tile drains	1,154.58	287.69	1,442.27
Miscellaneous	228.15	9.44	237.59
Grand total	20,532.72	1,741.12	22,273.84

BUILDING CONSTRUCTION.

The building construction work was transferred to the quartermaster's department on July 1, 1909, by special arrangement. This division completed certain buildings under way at that time. Details are given in Table 30.

TABLE 30.—*Building construction.*

Description.	Labor.	Material.	Total.
Powder magazine and detonator house, Ancon	$255.37	$12.67	$268.04
New corral, Ancon	20.08	92.25	112.33
Cement shed, Miraflores	1,731.01	3,512.85	5,243.86
Field office, Pedro Miguel	405.57	182.81	588.38
Skylight, division office, Corozal	7.24	....	7.24
Total	2,419.27	3,800.58	6,219.85

Fourth District.

ANCON QUARRY AND CRUSHERS.

[J. A. Loulan, superintendent.]

The general arrangement of the Ancon quarry and crushers was shown on Plates 57 and 58 of the last annual report. The plant was practically ready for operation in October, 1909, when a slide occurred on the face of the hill between the crushers and storage bin, threatening, for a time, the destruction of the latter. This necessitated removing 40,960 cubic yards of earth, building a large amount of rock-filled cribwork, and replacing the conveyor connecting the crushers and bin, which had been taken down when the slide began. The plant was started on February 10, 1910, and all subsequent work has been stripping, quarrying, crushing, and maintenance of plant and equipment.

Performance of Ancon quarry and crushers is shown in Table 31.

Table 31.—*Performance of Ancon quarry and crushers.*

Month.	Number of 8-hour days.	Average number of shovels.	Excavated.			Crushed and supplied.				
			Graded.	Stripped.	Quarried.	Locks.	Municipal department work.	Other Pacific division work.	Other divisions, departments, etc.	Total.
			Cu. yds.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*
1909.										
July	26	2.30	41,444							
August	26	2.19	50,475							
September	25	2.56	45,286							
October	26	3.35	44,219							
November	23	3.40	28,770	20,712						
December	26	3.58	12,190	33,582						
1910.										
January	25	3.60		45,350						
February	23	3.35		25,279	23,281	21,665	196	1,396	24	23,281
March	26	4.00		37,376	47,424	36,053	1,077	10,118	176	47,424
April	26	2.66		13,606	39,204	30,338	5,429	2,792	645	39,204
May	25	1.60		3,779	32,261	26,378	3,313	2,499	71	32,261
June	26	2.23		7,756	33,004	28,477	3,132	1,320	75	33,004
Total	303	2.90	222,384	187,440	175,174	142,911	13,147	18,125	991	175,174

In order to secure screenings for road surfacing and concrete finishing, a small-jaw crusher has been installed which reduces the size to a half inch or less. It is fed directly from one of the storage-bin pockets and produces from 30 to 40 cubic yards of finishing material per day.

In addition to the steam shovels recorded in the above table, one shovel has been engaged since April in excavating rock for backfilling the lock walls. The backfilling follows the construction as closely as possible, and large rock are selected from the filling and placed in the concrete. This shovel has excavated 19,690 cubic yards, of which 9,616 cubic yards were used for backfill.

Surveys, Maps, and Office Work.

SURVEYS.

A survey was made of Culebra Island Bay to determine the location of a landing stage for the quarantine station and a topographical survey made of Flamenco Island by request of the fortification board.

The site proposed for a terminal basin at Balboa was surveyed, and a number of minor surveys made for municipal improvements and extensions in the Canal Zone and city of Panama.

MAPS.

Maps were prepared showing in detail the sanitary districts of Ancon, Balboa, Corozal, Miraflores, and Pedro Miguel. Eight sheets of a detailed map of the Pacific division were completed; the locks, dams, canal prism, topography, location of buildings, roads, sewers, and water mains are shown on a scale of 1: 2,000, and each sheet covers an area approximately 11,000 by 6,500 feet.

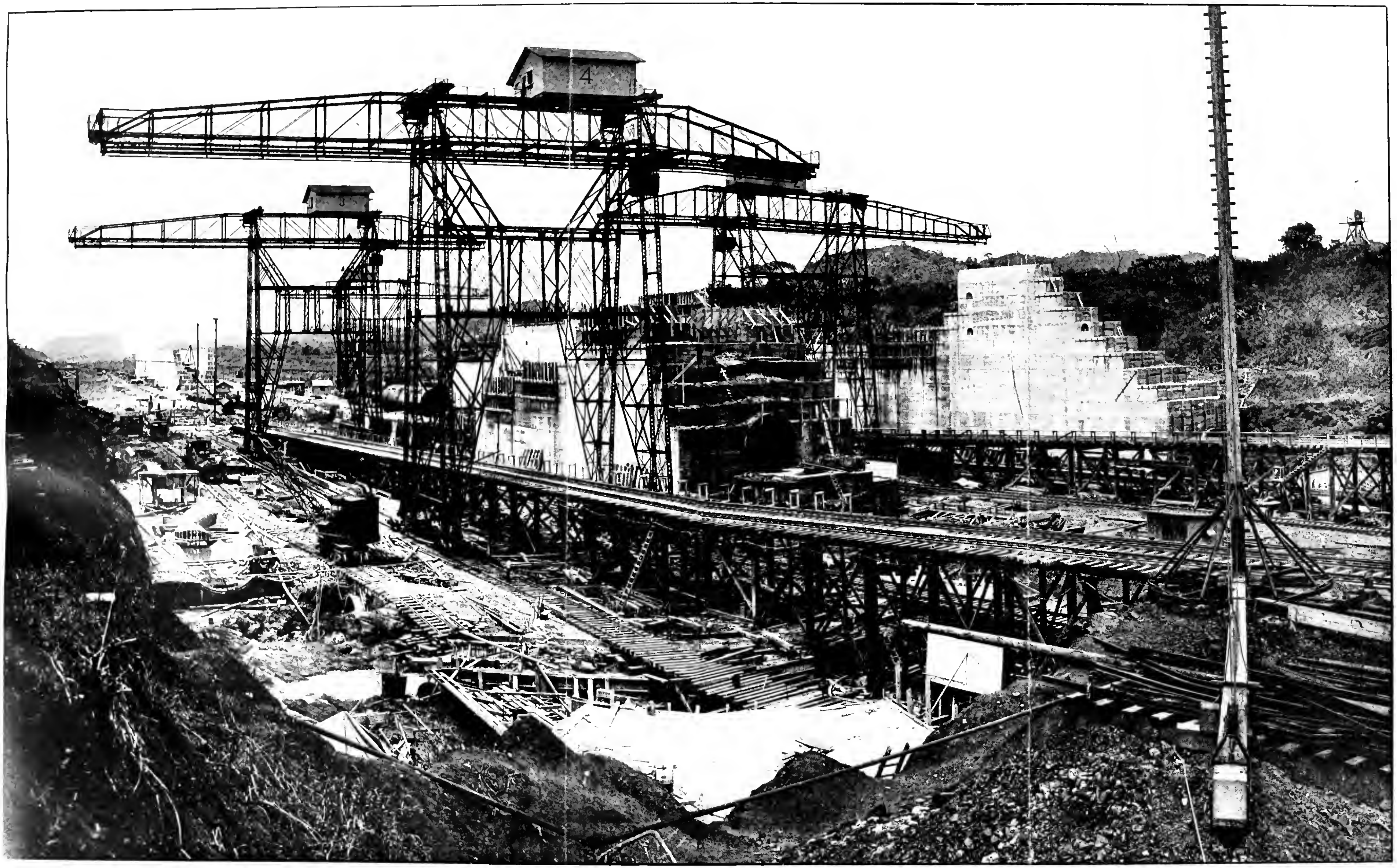
OFFICE WORK.

In addition to the routine office work, designs, estimates, and, when necessary, specifications were prepared for the Cocoli pumping and filtration plant, the central station of the hydraulic excavating plant, the Pedro Miguel and Balboa electrical substations, reinforced concrete barges, reinforced concrete reservoirs at Naos Island and Palo Seco, storage trestles at Miraflores, auxiliary concrete mixing plants at Pedro Miguel and Miraflores, a division telephone system, and concrete forms. In all, 312 complete drawings were made, including, in addition to the above, a number of mechanical details of repair parts for the machinery in use on the division.

Respectfully,

S. B. Williamson,
Division Engineer.

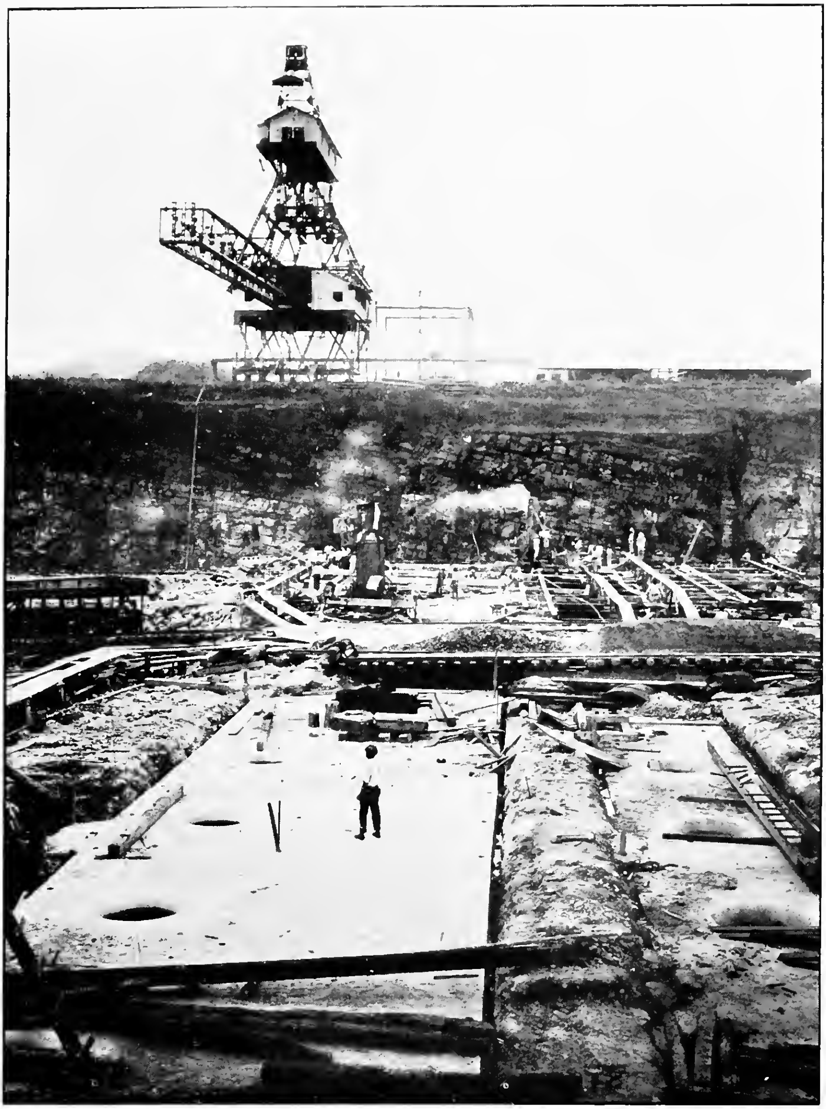
Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.



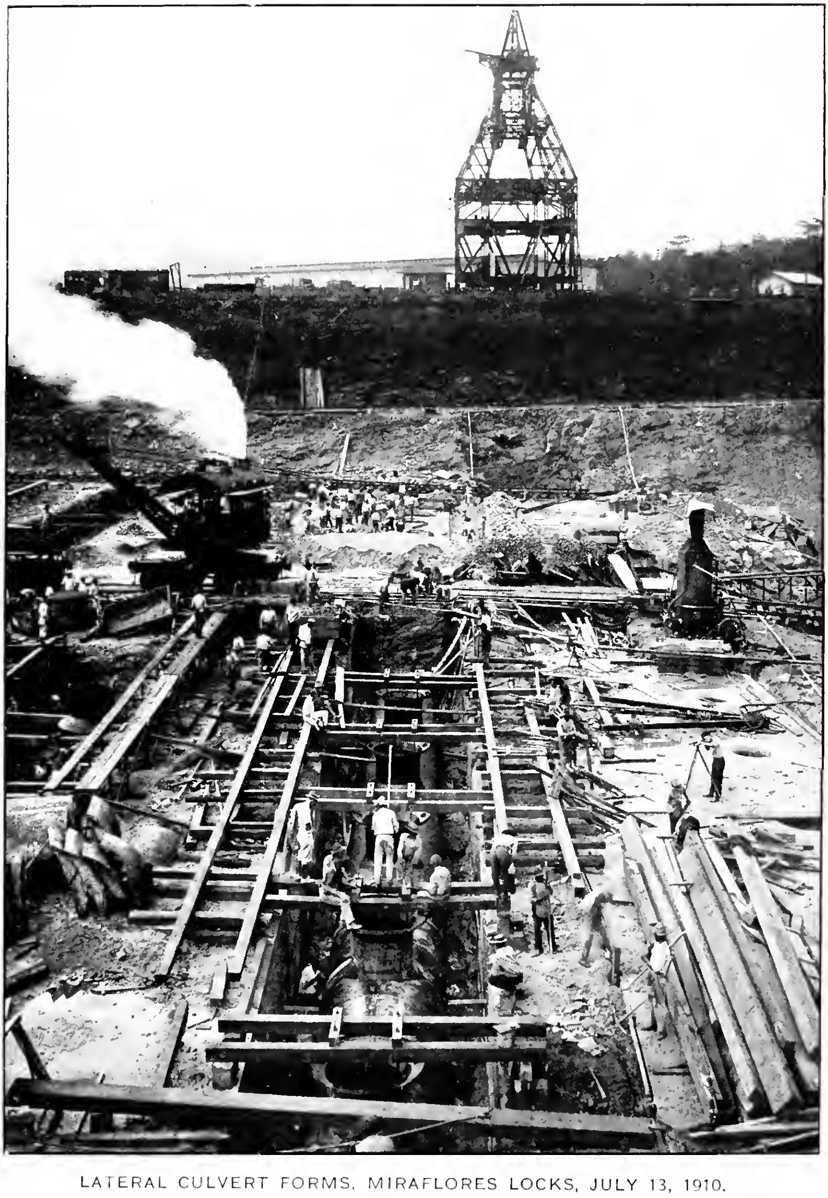
GENERAL VIEW OF PEDRO MIGUEL LOCK, LOOKING SOUTH, JUNE 30, 1910.

COMPLETED SECTION OF PEDRO MIGUEL LOCK FLOOR, LOOKING NORTH, SHOWING CHAMBER CRANE, JANUARY 5, 1910.

MIXING CRANES AND STORAGE TRESTLES IN FOREBAY AT PEDRO MIGUEL LOCK, LOOKING SOUTH, JUNE 30, 1910.

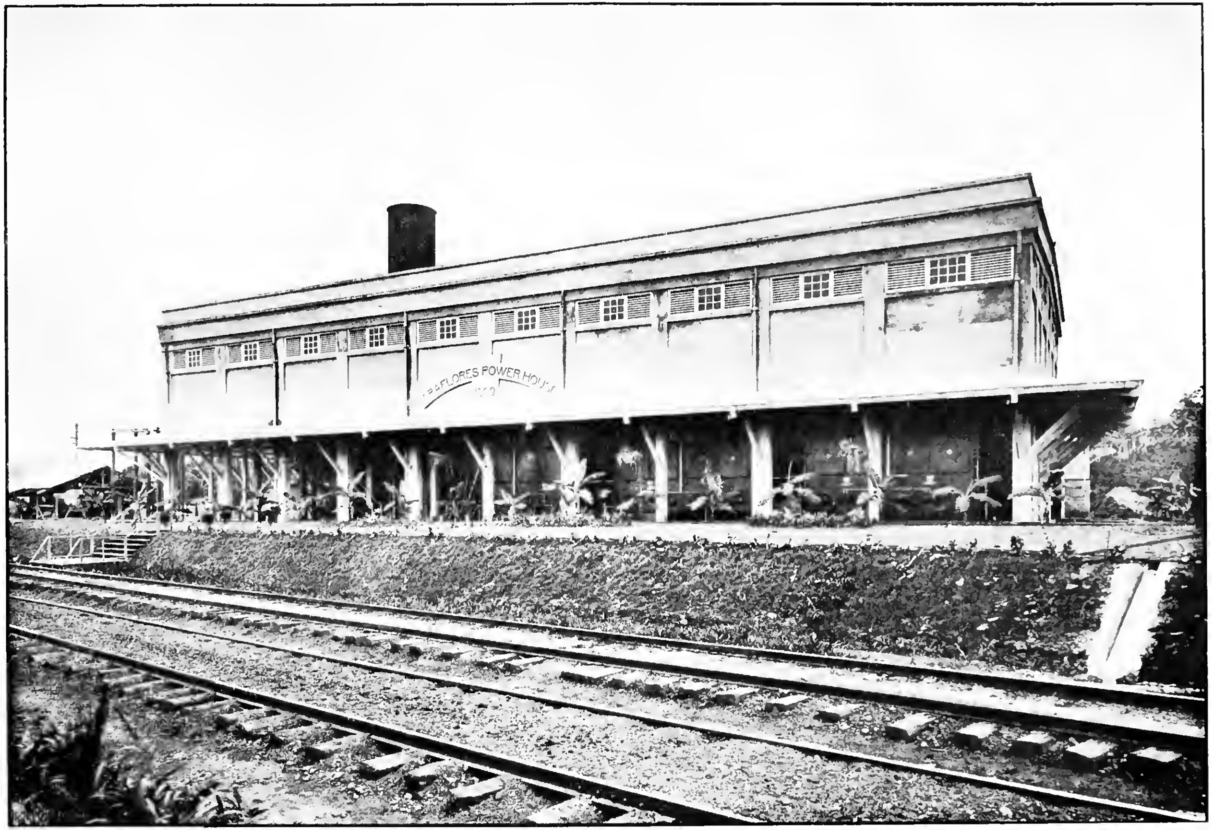


LATERAL CULVERT FORMS AND FLOOR, MIRAFLORES LOCKS, JULY 13, 1910.

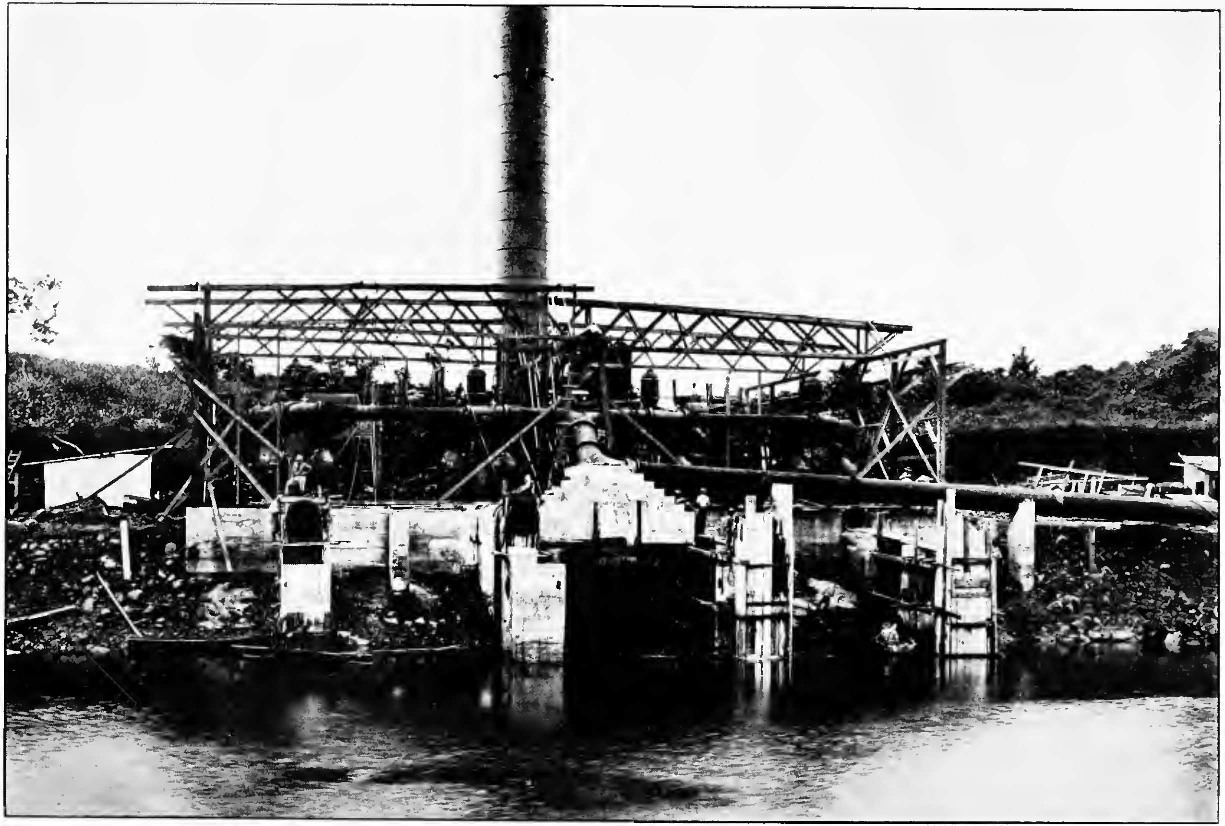


LATERAL CULVERT FORMS, MIRAFLORES LOCKS, JULY 13, 1910.

PLATE 47.



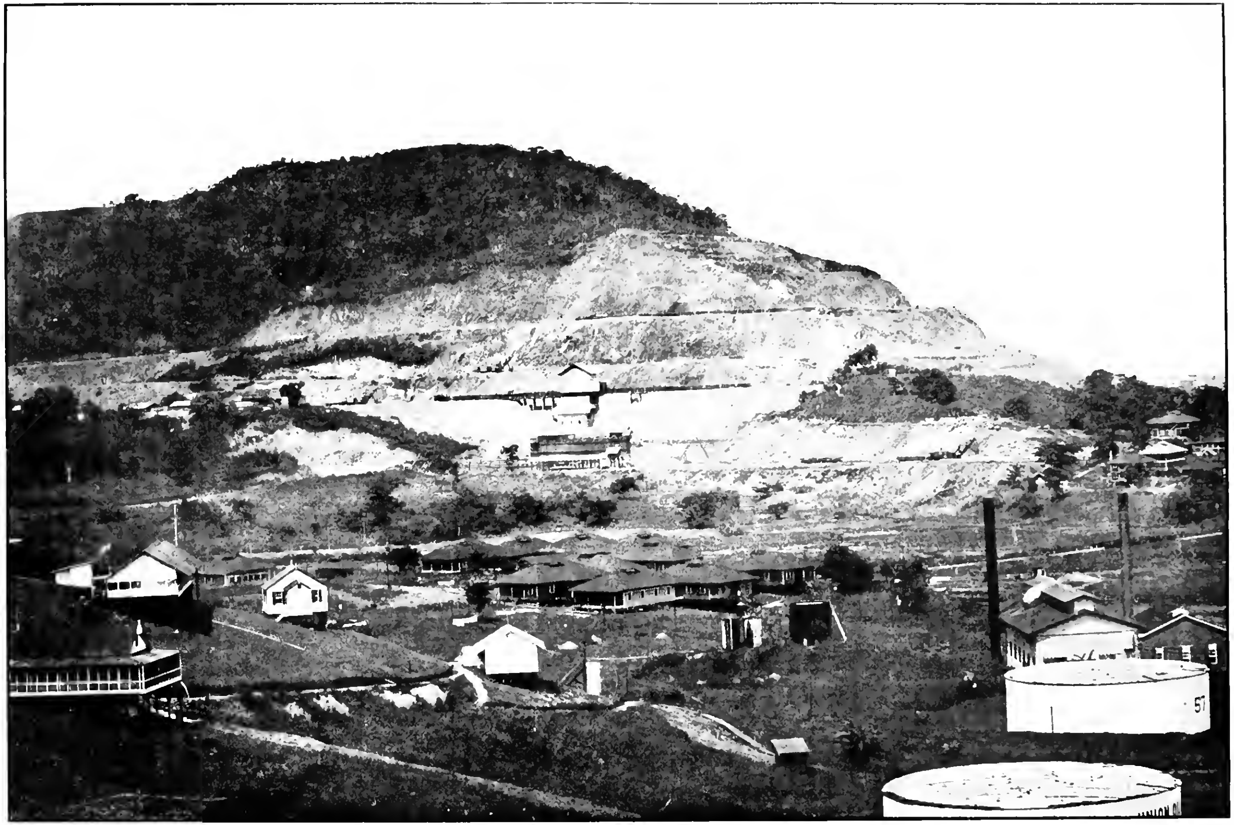
REINFORCED CONCRETE POWER HOUSE AT MIRAFLORES, JUNE 30, 1910.



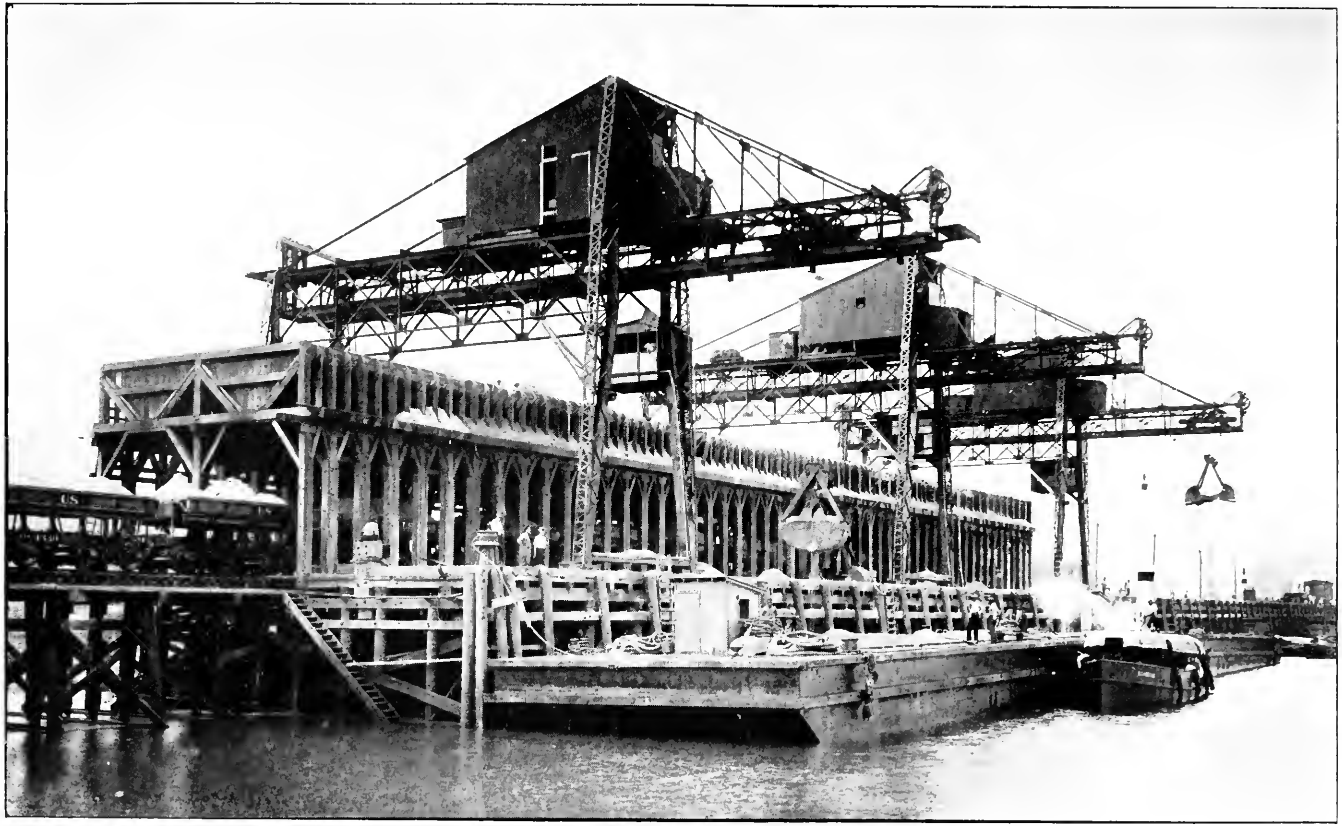
CENTRAL PUMPING STATION, HYDRAULIC EXCAVATING PLANT AT AGUA DULCE, DURING ERECTION, JUNE 30, 1910.

REINFORCED CONCRETE BARGE. INTERIOR VIEW SHOWING REINFORCEMENT OF BULKHEADS AND GIRDERS, MAY, 1910.

LAUNCHING REINFORCED CONCRETE BARGE, PACIFIC DIVISION, JUNE, 1910.



GENERAL VIEW OF ANCON QUARRY, JUNE 30, 1910.



SAND UNLOADING CRANES AT BALBOA, APRIL 21, 1910.

REINFORCED CONCRETE RESERVOIR, 100,000 GALLONS CAPACITY, AT NAOS ISLAND, 1910.

APPENDIX F.

REPORT OF THE ENGINEERING DEPARTMENT OF THE PANAMA RAILROAD.

Panama Railroad Company,
Office of Chief Engineer,
Colon, Panama, July 1, 1910.

Report of Engineering Department for the Year Ending June 30, 1910.

As explained in past annual reports, the relocating and rebuilding of the Panama Railroad was made necessary by the plans of the Canal Commission for a lock canal, which will create a large artificial lake in the valley of the Chagres River, completely submerging the present operated line for a greater part of its length. Surveys for the new line started in August, 1906. Construction work was commenced in May, 1907, and has continued without interruption since that date.

At the beginning of the fiscal year 1909–10 the entire line was under construction except the stretch of about 8 miles through the valley of the Gatun River, and during the period to which this report pertains the gap was closed, giving a continuous track over the new line from Gatun to the Culebra cut.

Construction work is naturally divided into two parts by the Culebra cut, one section extending from Gatun to the north end of Culebra cut at Gamboa, and the other section from the south end of Culebra cut to Corozal. Under existing plans the relocated line will be carried through Culebra cut on the east berm at the 95-foot level.

JOINING TRACK FOR EMERGENCY TRAFFIC.

By reference to the general map of the relocated line from Colon to Bas Obispo (Pl. 120), the location of the ends of standard-gauge track can be seen as they existed on July 1, 1909, 9¼ miles apart. The problem was largely to close this gap, thus giving a high-level line through the Chagres Valley, which would permit the Atlantic division to turn the waters of the Chagres River through the spillway channel without fear of absolutely cutting off traffic across the Isthmus by flooding the lower level tracks of the operated line. The drainage of the Chagres Valley had been passing out to sea through what is known as the west diversion, with the top of water in ordinary stage at about +3 above mean sea level, and when this channel was closed it forced the waters through the artificial channel of the spillway, thus narrowing the outlet and putting top of water in ordinary stage to about +15. This flooded area of about 20 square miles is indicated on attached map. (Pl. 120.)

These operations, essential in the construction of the Gatun dam, subjected the operated line between Gatun and Bohio to an ever-present danger from floods, which would interrupt traffic across the Isthmus. Work on this portion of the relocation was therefore pushed in order to have this through route ready and available to be used in case of necessity. Track was actually connected over a shoo-fly line on March 28, 1910, and over the 60-foot level, according to plan, on April 13, 1910.

GATUN RIDGE LINE.

Standard track had reached a point about 3 miles from Gatun at the close of the fiscal year June 30, 1909, and temporary hand-grading work had reached a point about one-half mile further on. A large construction camp was established at the end of track, consisting of white foremen's quarters, laborers' quarters, and commissary, which would permit the construction forces to be taken care of in close proximity to the work without loss of time going to and fro.

The Quebrancha bottom was reached by the middle of December. Grading for this mile from end of track to the Quebrancha was the heaviest on the line and consisted entirely of steam-shovel excavation, which aggregated in all about 600,000 cubic yards in a prism of standard section. Of this amount, 465,000 cubic yards have been excavated during the year, some of the material being used to make small embankments and the rest hauled to the large embankments of the Quebrancha bottom. There still remains considerable yardage to move over this section of the line, but practically all cuts are down to grade, the slopes of some being left from which material can be obtained to make the fills across the valley.

CROSSING THE GATUN VALLEY.

After leaving solid support on the ridge, the line for about 2½ miles crosses low country, drained by the Gatun River and its tributaries. These streams and bottoms, named in order from north to south, are the Quebrancha, the Brazo, the Baja, and the main Gatun River. They are all low, requiring embankments ranging from 60 to 70 feet high, which will contain, in the aggregate, about 3,500,000 cubic yards. The first of these big fills, the Quebrancha, 1,800 feet long, and to contain 800,000 cubic yards, was reached about January 1, and a trestle driven at elevation +50 to put in the first level. The accompanying photograph (Pl. 54), looking north, shows the state of completion of this fill in the month of June, 1910, and illustrates the method of building it by different levels. By that date 200,000 cubic yards had been placed in the first level.

A triple 6 by 8 reenforced box was constructed close to the old creek bed, benched in on solid rock foundation, to carry the waters of the upper valley. The soundings over this bottom range from 150 to 180 feet to solid rock and show a soft deposit of sandy clay, covered over by a harder stratum of clay and pure sand, ranging from 30 to 50 feet in thickness. The foundation of this fill is being spread widely to distribute the weight, in order to avoid any possibility of settlement by overloading.

The next and largest bottom, the Brazo, 4,200 feet long, and to contain 1,500,000 cubic yards, was reached in February, and a pile driver started, headed south, driving a temporary trestle at +60 level. At the same time a temporary construction track was laid on the ground the entire length of the bottom, and a second driver started, headed north. In this manner, using two pile drivers, and supplying them with material from the shoo-fly line, this long trestle was driven with the greatest speed. The accompanying photograph (Pl. 55) shows this bottom, looking south. No filling has been done during the present year.

The next bottom, the Baja, is not so long as the others, being 1,500 feet long, and containing 500,000 cubic yards. The work of filling the temporary trestle was commenced in April, and the accompanying photographs, looking south (Pl. 56) and north (Pl. 57), show the state of completion of this fill in the month of June, at which time some 150,000 cubic yards had been placed. The next and last big embankment, 3,800 feet long, and to contain 1,000,000 cubic yards, occupies the valley of the Gatun River, and the temporary trestle over this was completed by the end of February. A general view of this valley, taken from the south end, is shown in Plate 58. Only a start was made at putting in the filling for the first level. The trestle is left open at the south end as it crosses the site of the waterway through the proposed permanent bridge, described later.

Over all these bottom lands the first trestle was driven off center, below permanent level, and so located that all work would fall within the prism of the permanent line. These immense embankments are being built after plan shown by accompanying cross section (Pl. 121), which will leave one track at elevation 50 or 60 always available during the process of construction, as it is quite likely that this track will have to be used from time to time to accommodate main-line traffic across the Isthmus. For like reason the crossing of the Gatun River on the 60-foot level was made secure by installing two-plate girder spans, resting on pile piers, shown in accompanying photograph (Pl. 59). The channel span is one of the old Barbacoas girders, taken out of the main-line bridge across the Chagres River at San Pablo, and used here on a shorter span. This temporary bridge will later be replaced by three steel-plate girder spans on the 95 level, at a different location, which is indicated on photograph (Pl. 58). One of these girder spans will be converted into a lift span, to permit access to the upper arm of Gatun Lake.

FROM GATUN RIVER TO FRIJOLES.

At the beginning of the year, July 1, track had been pushed out from Frijoles to station 746, a point about 1½ miles south of Bohio Ridge. Hand grading forces were at work over practically all of the line from end of track to the Gatun River. About three-fourths of a mile of the section immediately north of Bohio Ridge was let out to a contractor and graded at a unit price per cubic yard. Track was laid ahead over this section a distance of about 6 miles as fast as the roadbed was ready, and the Gatun River was reached about the middle of January. An average of four steam shovels were constantly at work cutting down grades and borrowing to complete

fills. This section of 8 miles only lacks about six weeks' work to complete everything to permanent grade.

A new box car grading camp was established at Monte Lirio to house white foremen and colored laborers.

FRIJOLES TO GAMBOA BRIDGE.

At the beginning of the fiscal year, July 1, 1909, there existed a gap of about a mile between the track laid south from Frijoles section and the track laid north from Caimito section. This gap was closed in the early part of the year, and track is now continuous, on permanent grade and center, over this section. There remains but a few weeks' work for one steam shovel excavating heavy slopes and slides.

The portion of the line from the Caimito section south to Gamboa Bridge is practically complete, and was turned over to the central division in the early part of the fiscal year. This section has been used to develop waste dumps for the spoil from the Culebra cut, which is hauled out over the new Gamboa Bridge on the 95 level.

PARAISO TO COROZAL.

This part of the relocated line leaves the present operated line, on the east berm of the canal, at 95 level in the vicinity of Paraiso, and drops down an easy grade, reaching the level of the operated line in the vicinity of Corozal. It was determined early in the year to push the work on this section, in order that the double-track operated line might be turned over to the Canal Commission for their sole use in moving spoil trains. This section of line is about 4 miles long, and consists largely of embankments made from the spoil of the Culebra cut. In order to secure good alignment for the new high-level line, it was necessary to divert a part of the operated line and rebuild it before we could proceed with the construction of the new line. Maintaining heavy traffic over this stretch, coupled with slides and settlements in high embankments, has caused unavoidable delays which have retarded the work. This line is now practically complete, laid with new 90-pound rail, and ballasted, and to be ready for traffic by August 15 next. Two temporary stations were built to replace those of the old line which were abandoned—one at Pedro Miguel and the other at Miraflores.

A new interlocking plant is to be installed at either end of this line to control the movement of all trains over the single track.

PERMANENT CULVERTS.

A number of important permanent culverts were constructed during the dry-season months of January to April, and temporary open trestles over the streams filled in to grade. A triple 6 by 8 reinforced concrete box was constructed at the Quebrancha, near Gatun Ridge (Pl. 122), and a double 15 by 20 reinforced concrete box (Pl. 60) was constructed at the Agua Salud River, station 800. A 20-foot reinforced concrete arch (Pl. 61) was constructed at the Frijolito River, station 450. A double 12 by 15 reinforced concrete box was constructed on the Paraiso-Corozal section, to carry the

Cardenas River, formerly flowing through an open trestle at Bridge 62, operated line. Plan and section of these culverts is shown on Plate 123.

Besides these culverts, numerous small concrete arches and boxes were installed at the lesser streams, and in all about 17,000 cubic yards concrete and 1,000 tons reinforcing iron were placed in culverts during the year. Statement of cost of these structures follows:

Culvert at the Frijolito River.

Station 849 + 61, 20 by 20 foot arch culvert.
Length, 133 feet.
Excavation, 35,820 cubic yards.

	Unit.	Cost per unit.	Amount.
B & B and S. S. labor, excavating	Cubic yard	$0.55893	$20,021.46
Driving piles, 2,480 linear feet:			
Labor	Foot	.6722	1,667.25
Material	do	.1803	447.25
Total		.8525	2,114.50
Placing concrete, 2,666 cubic yards:			
Labor	Cubic yard	2.734	7,288.60
Material	do	3.25	8,665.53
Total		5.984	15,954.13
Cost of hardware			2,843.40

SUMMARY.

B & B labor	$14,086.10
Steam shovel	14,871.20
Material	11,956.18
Total	40,913.48

Total cost per yard of concrete placed in culvert, $15.3484.

Culvert at Quebrancha, station + 27, Gatun.

Triple 6 by 8 box; length, 309 feet.
Excavation, 4,630 cubic yards.

	Unit.	Cost per unit.	Amount.
Labor, excavating	Cubic yard	$0.7677	$3,554.75
Placing concrete, 2,725 cubic yards:			
Labor	do	2.6269	7,158.35
Material	do	2.8474	7,759.36
Total		5.4743	14,917.71
Cost of hardware			1,609.36

SUMMARY.

B. & B. labor	$7,795.50
Task labor	2,917.60
Material	9,368.72
Total	20,081.82

Total cost per cubic yard of concrete placed in culvert, $7.3694.

Culvert at Agua Salud River, station 804.

Double 15 by 20 foot flat top; length 89 feet.
Excavation, 7,250 cubic yards.

	Unit.	Cost per unit.	Amount.
B. & B. and task labor, excavating	Cubic yard	$0.7486	$5,427.15
Driving piles, 8,238 linear feet:			
Labor	Foot	.1853	1,526.30
Material	do	.2007	1,653.81
Total		.3860	3,180.11
Placing concrete, 2,504 cubic yards:			
Labor	Cubic yard	2.995	7,499.15
Material	do	3.5215	8,817.20
Total		6.5165	16,316.35
Cost of hardware			2,192.20

SUMMARY.

B. & B. labor	$10,674.40
Task labor	3,778.20
Material	12,663.21
Total	27,115.81

Total cost per cubic yard of concrete in culvert, $10.8289.

BALLAST.

Our forces have been very active, particularly during the dry season, in ballasting such portions of the relocated line as were on permanent grade and center. Some 18,000 cubic yards have been hauled from the Gorgona gravel pit, operated by the maintenance of way department, and placed under track. In the early part of the dry season a new gravel pit was opened up under relocation account in the Chagres River, about 1 mile above the new Gamboa Bridge. A steam shovel was at first installed and loaded this gravel in the dry until the top of the pit was exhausted. Later, a crane with clam-shell bucket worked all over the same area, and in all about 42,000 cubic yards were excavated. Of this amount about 18,000 cubic yards were hauled directly to the relocated line and used as ballast, and 24,000 cubic yards were placed in storage at a convenient point above high water and available for ballast during the rainy season.

SUMMARY.

During the year 2,500,000 cubic yards of material were excavated and 1,500,000 cubic yards canal spoil utilized.

Seventeen thousand cubic yards concrete and 1,000 tons reinforcing iron placed.

Twenty-five thousand linear feet of temporary trestle constructed; 400,000 linear feet piling in trestles, and 15,000 linear feet grillage piling driven.

Forty thousand untreated ties used, and ballast to the amount of 27,000 cubic yards.

Eight 70-ton steam shovels, 28 engines, 146 western dump cars, 3 pile drivers, 1 locomotive crane, and a large quantity of Decauville equipment have been used by a force averaging 2,700 men.

MOUNT HOPE LINE.

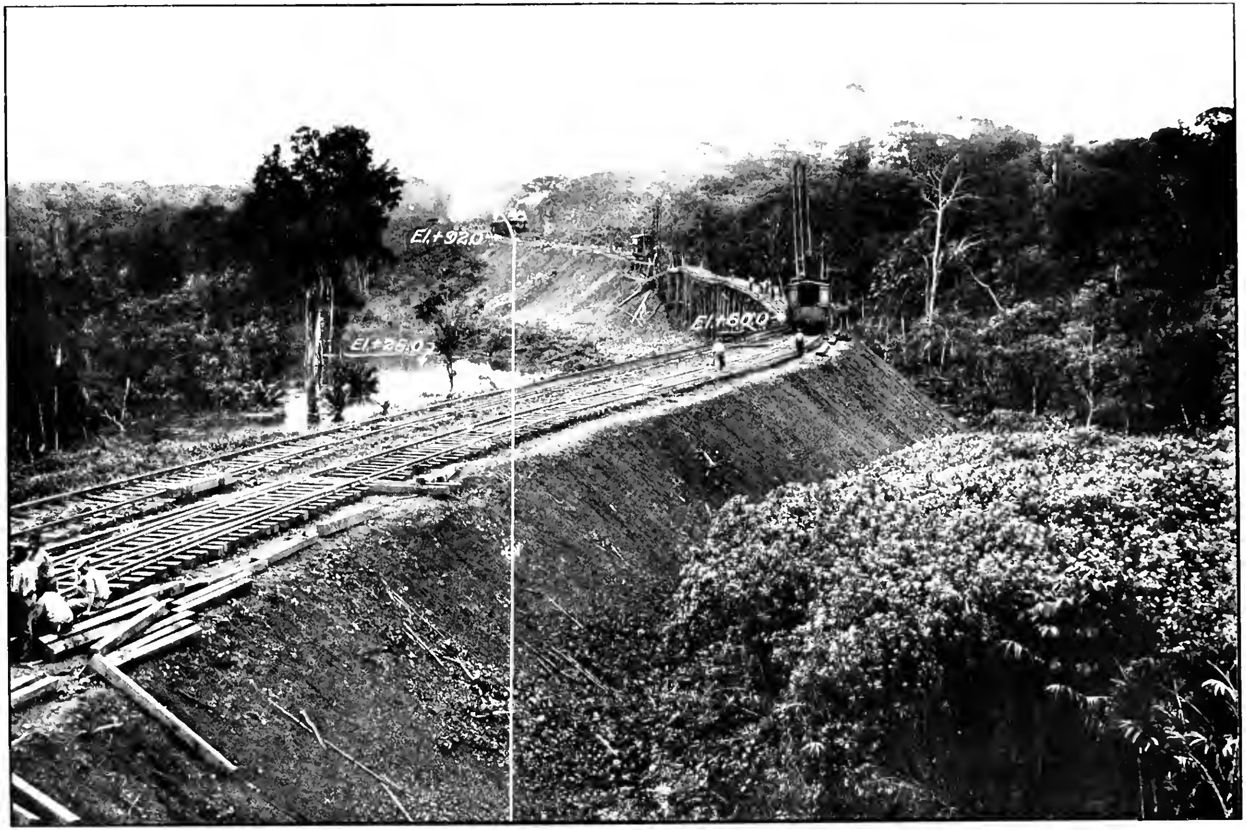
As a matter of record, it would be well to state that during the dry season a small engineering force was put into the field and a new cut-off line surveyed from Mount Hope to connect with the relocated line at the Quebrancha. This line was carefully and accurately located, lying entirely without the drainage of the Mount Hope Reservoir, and is shown on attached map. (Pl. 120.) A +0.5 per cent grade was secured over this route, southbound. It can be built for $300,000, and it will not only eliminate the pusher grade now existing from Mount Hope to Gatun, but it will cut off more than 5 miles in distance across the Isthmus.

Respectfully submitted.

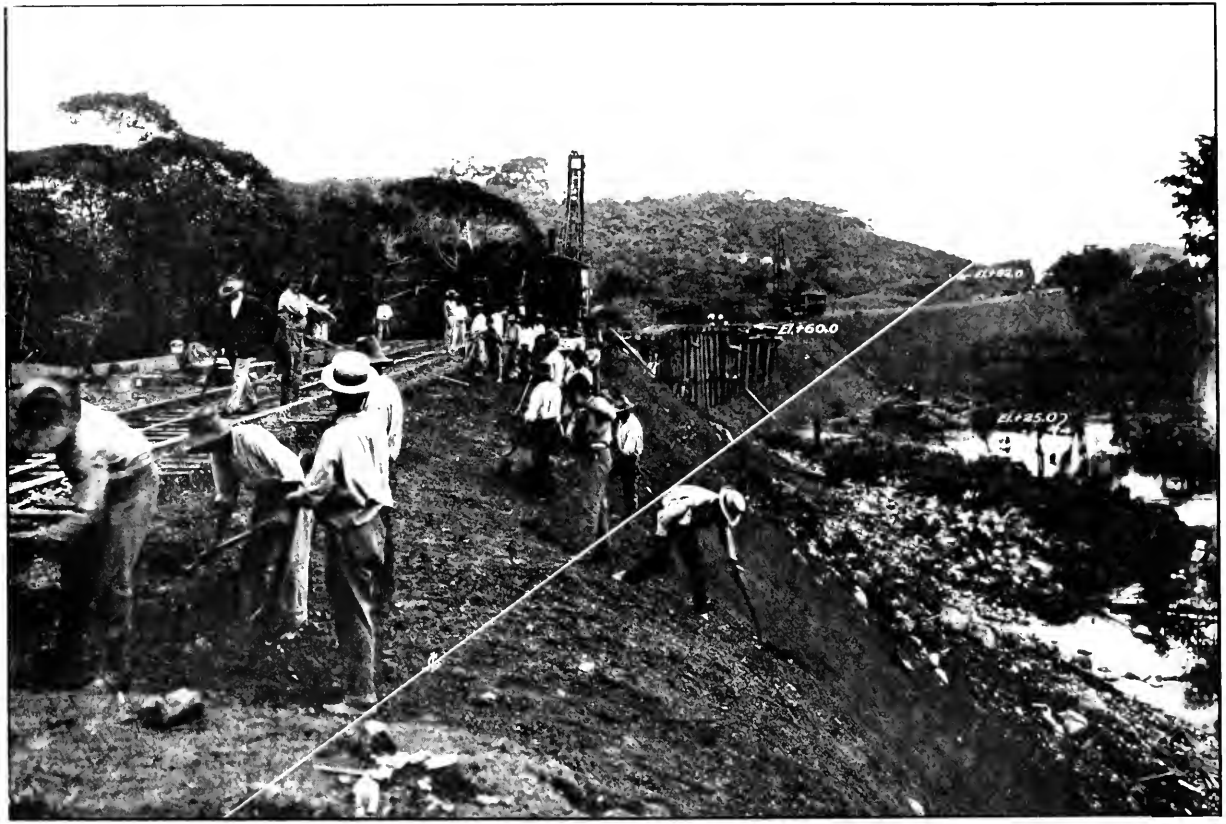
F. MEARS, *Chief Engineer.*

RELOCATION PANAMA RAILROAD. THE QUEBRANCHA BOTTOM, LOOKING NORTH. PUTTING IN THE FIRST DECK OF THIS FILL TO ELEVATION +50, JUNE, 1910.

RELOCATION PANAMA RAILROAD. THE BRAZO BOTTOM, LOOKING SOUTH. JUNE, 1910. THE EMBANKMENT ACROSS THIS VALLEY, 4,200 FEET LONG, WILL CONTAIN 1,500,000 CUBIC YARDS.

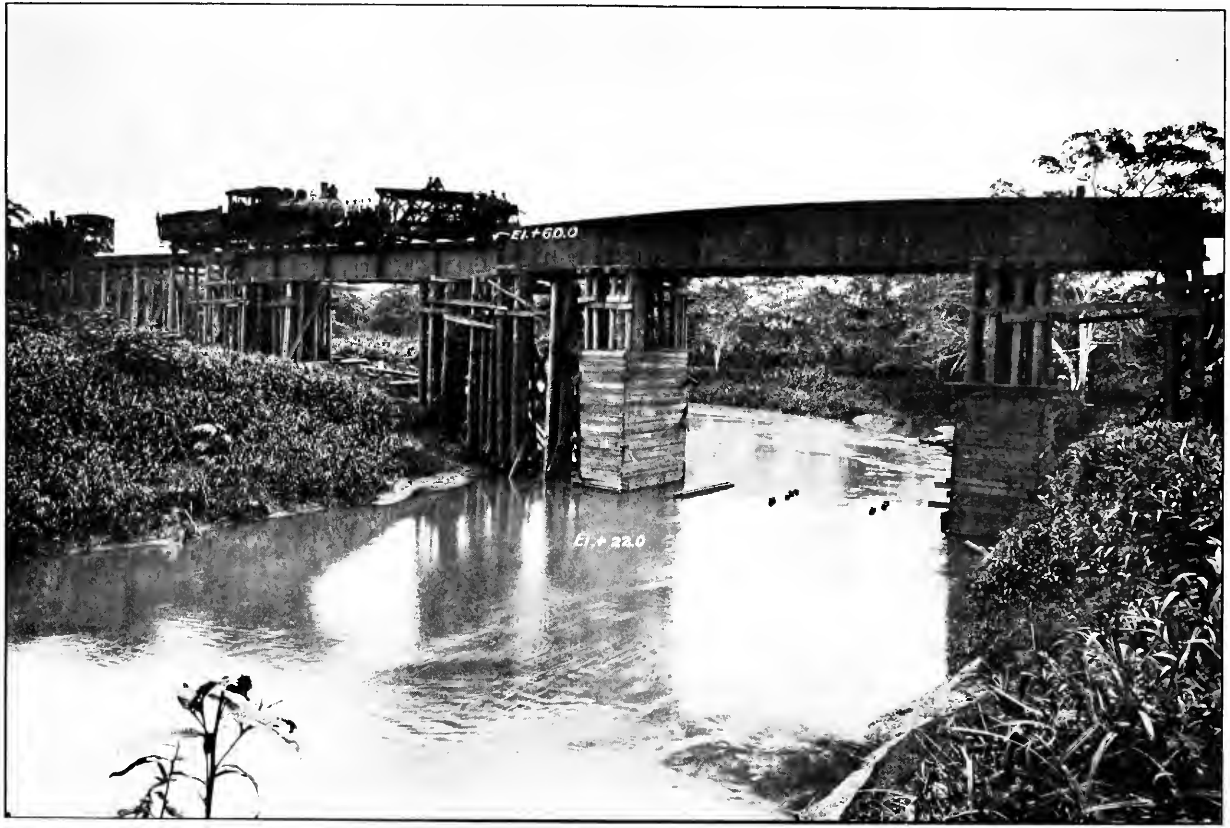


RELOCATION PANAMA RAILROAD. THE QUEBRADA BAJA BOTTOM, LOOKING SOUTH. JUNE, 1910. THE CONSTRUCTION TRESTLE WAS DRIVEN ON THE CURVE TO REDUCE HEIGHT AND SECURE BETTER BOTTOM.

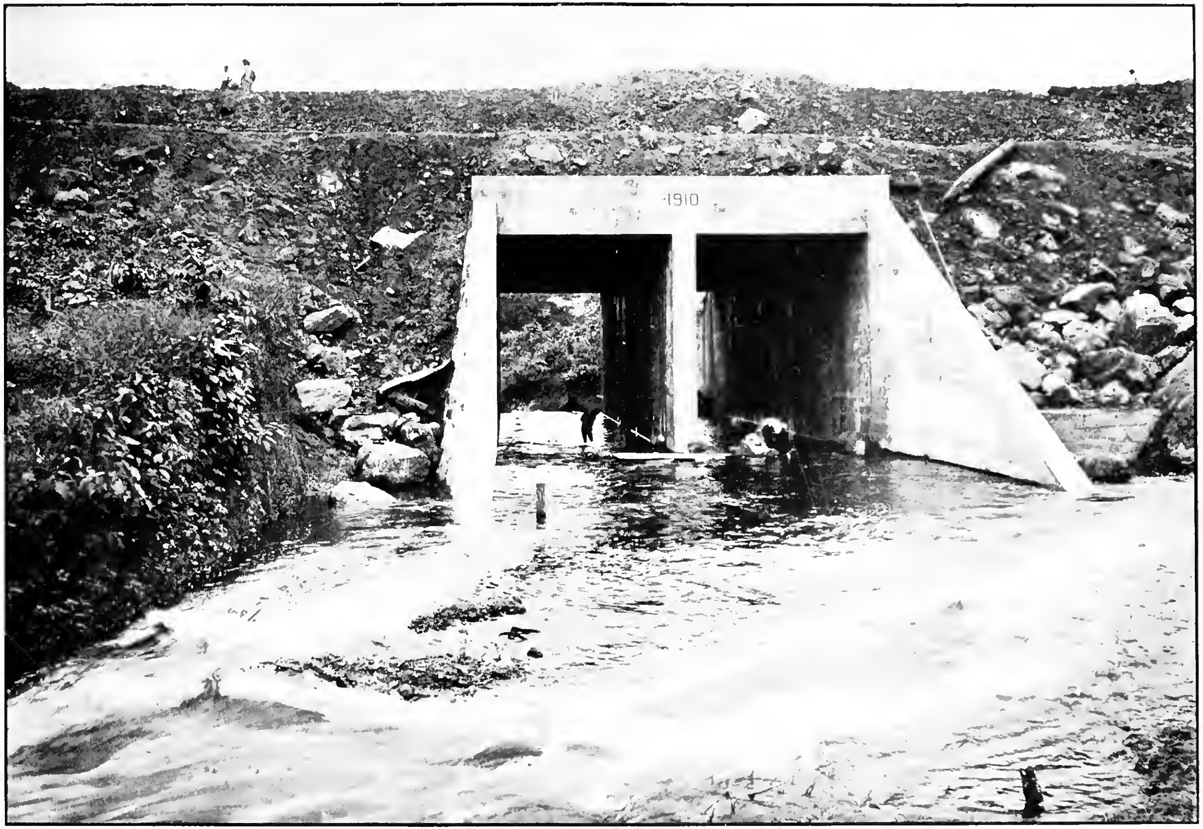


RELOCATION PANAMA RAILROAD. THE QUEBRADA BAJA BOTTOM, LOOKING NORTH, JUNE, 1910.

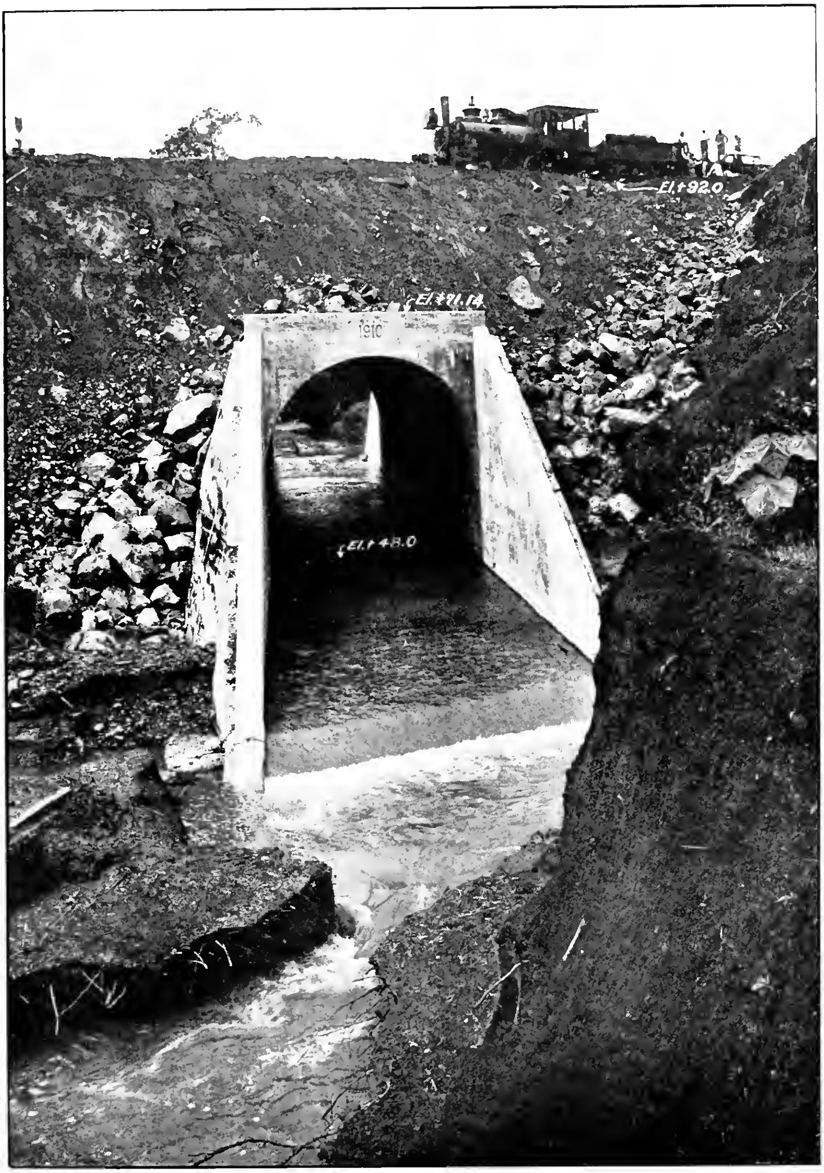
RELOCATION PANAMA RAILROAD. EMBANKMENT ACROSS THE VALLEY OF GATUN RIVER IN FIRST STAGE OF CONSTRUCTION, JUNE, 1910.



RELOCATION PANAMA RAILROAD. ONE OF THE OLD P. R. R. GIRDER SPANS TAKEN OUT OF THE BARBACOAS BRIDGE AT SAN PABLO. USED ON THIS TEMPORARY CROSSING OF THE GATUN RIVER AT MONTE LIRIO TO ACCOMMODATE TRAFFIC WHILE BUILDING THE PERMANENT BRIDGE. JUNE, 1910.



RELOCATION PANAMA RAILROAD. DOUBLE 15 BY 20 FOOT REINFORCED CONCRETE BOX AT AGUA SALUD RIVER. JUNE, 1910.



RELOCATION PANAMA RAILROAD. TWENTY-FOOT REINFORCED CONCRETE ARCH CULVERT AT FRIJOLITO RIVER, JUNE, 1910.

APPENDIX G.

REPORT OF CIVIL ENGINEER H. H. ROUSSEAU, U. S. NAVY, MEMBER OF ISTHMIAN CANAL COMMISSION, ASSISTANT TO THE CHIEF ENGINEER, IN CHARGE OF THE SECOND DIVISION OF THE OFFICE OF THE CHIEF ENGINEER.

Isthmian Canal Commission,
Office of the Chief Engineer, Second Division,
Culebra, Canal Zone, August 1, 1910.

Sir: In compliance with your order of June 24, 1910, I have the honor to submit the following report covering the second division of the office of the Chairman and Chief Engineer for the fiscal year ended June 30, 1910.

The total appropriations by Congress available to June 30, 1910, were $210,146,468.58, or 56 per cent of the total estimate of December, 1908, of $375,201,000. On June 25, 1910, additional appropriations amounting to $37,855,000 for the fiscal year 1910–11 were made, leaving $127,199,531.42 of the total estimated cost of the canal to be appropriated.

To June 30, 1910, the classified expenditures, i. e., expenditures which have been charged into the work, amounted to $191,258,113.93, or about 51 per cent of the total estimate. Of this latter amount, $31,188,426.37 were the net expenditures during the fiscal year covered by this report, or 8.3 per cent of the total estimate of $375,201,000. The difference between the appropriations and the classified expenditures, amounting to about $18,888,354.65, represents such items as balances in appropriations, material and supplies on hand in storehouses and in process of manufacture, amounts deposited in the United States Treasury as "miscellaneous receipts," and other unclassified items of expenditure which have never been carried to the work, as appear fully in Appendix No. 1 of the examiner of accounts' annual report.

The quantity of work performed to June 30, 1910, for the three principal items, the total estimated amounts, and the amounts performed during the fiscal year 1909–10, are as follows:

Item of work.	Estimated total quantity (cubic yards).	Completed to June 30, 1910.		Performed during fiscal year 1909–10.	
		Cubic yards.	Per cent of total.	Cubic yards.	Per cent of total.
Excavation:					
Dry	111,768,000	68,746,000	61	19,903,000	18
Wet	70,770,000	42,018,000	60	11,955,000	17
Total	182,538,000	110,764,000	61	31,858,000	17
Concrete	4,520,800	771,200	17	739,000	16
Fill in dams	23,217,000	9,395,000	40	5,883,000	25

The accompanying chart (Pl. 124) shows graphically the excavation, concrete, fill, and the total expenditures to June 30, 1910.[a]

Of the total classified expenditures to June 30, 1910, $25,699,450.81 were for plant and equipment for construction, of which $4,388,511.55 were expended during the fiscal year covered by this report. The principal units of plant and equipment in use on July 1, 1910, ashore and afloat, by both the commission and Panama Railroad, are given in the following tables:

TABLE A.—*Statement of rolling stock in use by the different departments, as of July 1, 1910.*

Description.	Atlantic division.	Central division.	Pacific division.	Panama R. R.	Panama R. R., relocation.	Office of chief engineer.	Quartermaster's department.	Disbursing office.	Empire shop.	Gorgona shop.	Total.
Cars:											
50-ton, steel, flat	3	44	26	421	2						496
40-ton, wood, flat, "Lidgerwood"	3	1,671	12	102	2						1,790
12-yard western dump	58	266	154	5	103						586
18-yard western dump	130	153			8						291
6-yard Oliver dump	75										75
12-yard Oliver dump	33	298	115		35						481
Goodwin dump		12									12
Ingoldsby dump		12									12
Kinglawson dump		1		2							3
Pay-certificate car								1			1
Cranes (various)	21	8	10	4	1		5		3	7	59
Locomotives:											
201-class, American Locomotive Works	6	86	8								100
301-class, Baldwin Locomotive Works	7	25	8								40
400-class	5	4	3	2	5		1		3	1	24
500-class	9	25	9							1	44
600-class	1	19									20
700-class	9	4	19	1	4						37
800-class (narrow gauge)	18		10								28
Special									1	1	2
Motor cars	1	1	1			2					5
Velocipedes						1					1
Steam shovels:											
Model 20 Marion					1						1
Model 60 Marion	1	3	3								7
Model 91 Marion	2	10	4		1						17
45-ton Bucyrus	5	5	2		1						13
70-ton Bucyrus	11	15	2		7						35
95-ton Bucyrus		32	1								33
Spreaders	2	15	4		4						25
Unloaders		25	1		1						27
Track shifters	1	6	3								10
Pile drivers	3	6	3		5						17

[a] The chart shows graphically the monthly rate of progress of the work and expenditures. The curves do not begin at zero but start at the point representing the total estimated work to be done, or the total estimated cost. The ordinate of any point of a curve reading from the zero line, which is at the top, will, therefore, when referred to the proper scale on the side of the chart, show the amount of work remaining to be done, or the unexpended balance of the total estimated cost; as, for example, if it is desired to find the estimated cost of the work still to be done on June 1, 1909, find this date on the top line; follow the vertical line until the proper curve is reached; from this point follow a horizontal line to intersect the proper scale on the side of the chart.

TABLE B.—*Statement of floating equipment in use by the different departments, as of July 1, 1910.*

Description.	Atlantic division.	Pacific division.	Quarter-master's department.	Sanitary department.	Civil administration.	Total.
Barges:						
Cement barges	6					6
Coal barges	2	2				4
Coal barges, O F S	1					1
House-boat barges	1	1				2
Mud-dump barges	10	7				17
Stone and sand barges	14	6				20
Steel-dump barges		4				4
Rock-drill barges	1	1				2
Steel barges		3				3
Drill-driver barges	1					1
Rock-breaker barges		1				1
Wrecking barges		1				1
Disinfecting barges				1		1
Clapets	4	7				11
Gasoline launches	6	3	2	1	1	13
Dredges:						
Sea-going dredges, suction	1	1				2
Dipper dredges	2	1				3
Ladder dredges	3	4				7
20-inch suction dredges	4					4
18-inch suction dredge	1					1
Double-end clam-shell dredge	1					1
Steam cutters	2	1		1		4
Tugs:						
First class	6	2				8
Second class	3			1		4
Floating pile driver	1					1

TABLE C.—*Equipment owned by and operated on the main line of the Panama Railroad Company, as of July 1, 1910.*

ROLLING EQUIPMENT.

Locomotives:	
Road engines	36
Switch engines	27
Engines in Isthmian Canal Commission service	6
Total	69
Passenger cars:	
Special cars	5
First-class cars	22
Second-class cars	21
Baggage cars	2
Baggage and mail cars	6
Hospital cars	2
Local express cars	5
Total	63
Freight cars:	
Box cars	1,029
Freight cars—Continued:	
Coal cars	41
Flat cars	21
Fast freight cars	19
Total	1,110
Miscellaneous:	
Cabooses	20
Specie cars	2
Water-tank cars	3
Stock cars	20
Construction cars	12
Rodger ballast cars	200
Outfit cars	76
Pile-drivers (steam)	2
Wreckers (steam)	2
10-ton crane	1
25-ton crane	1
Refrigerator cars	22

FLOATING EQUIPMENT.

Tugs	3
Pilot boat, 12 horsepower	1
Floating pile-driver	1
Lighters	8
Coal lighters	4

The progress of construction work and daily unit costs of the different kinds of work depend largely on delays due to various causes, some of which are not preventable. It has been the endeavor to reduce delays on account of break-downs of machinery, equipment, and other plant to a minimum.

To effect this, as well as to provide facilities for overhauling plant and equipment and manufacturing such repair parts, etc., as might be required, each construction division has provided itself with adequate

repair shops and, in addition, there is a separate shop for handling heavy repairs to certain equipment and for large manufacturing jobs. A list of the different shops on the Isthmus together with the average number of men at work during the latter part of the fiscal year follows:

Number of employees.

Shop.	Gold.	Silver.	Total.	Work handled.
Atlantic division:				
Porto Bello shop	52	191	243	All repair work at Porto Bello.
Cristobal dry dock shop	287	578	865	Marine and general repair work.
Gatun locks machine shop.	60	200	260	Repair work.
Gatun dam machine shop.	3	39	42	Do.
Central division:				
Empire shop	160	209	369	Steam-shovel and drill repairs.
Pacific division:				
Cocoli machine shop	21	96	117	General repairs.
Balboa shop and shipways.	89	296	385	Marine and general repair work.
Mechanical division:				
Gorgona shop	523	661	1,184	Locomotive and general equipment repairs; general manufacturing shop.
Pedro Miguel engine house.	59	131	190	Light car and locomotive repairs and hostling locomotives.
Las Cascadas and Gamboa engine houses.	30	66	96	Do.
Quartermaster's department:				
Lirio planing mill	3	41	44	Manufactures doors and windows and does other millwork.
Total	1,287	2,508	3,795	

In addition to the foregoing the Panama Railroad has a general repair shop at Cristobal working 112 gold men and 484 silver men, or a total of 596 men, on repairs to its locomotives, cars, and other equipment. Also, in addition to the above, there are numerous small repair shops, employing a half-dozen or less men, distributed around the work where required and where economy has indicated the necessity thereof, where drill-sharpening and other small machine and blacksmith's work is done.

Cars converted into portable machine shops and repair shops are used as required and in a similar way floating machine shops are included in the facilities for repairing marine equipment. In the central division field repairs to steam shovels are handled by regular night repair gangs.

Over three-fourths of the hourly gold employees on the Isthmus are shop mechanics. The wage scale for gold mechanics has remained practically unchanged during the year, the base pay for first-class mechanics being, as heretofore, 65 cents an hour. During the year several petitions have been presented by the hourly gold employees for an increase in pay, the last request being for either a 20 per cent increase in pay or to be placed on the same basis as regards leave of absence privileges as the monthly gold employees of the commission, i. e., to be allowed six weeks' leave of absence with pay each year. In view of the fact that the Secretary of War, on September 25, 1909, granted the hourly gold employees of the commission two weeks' leave of absence with pay annually, under suitable regulations, effective January 1, 1910, as well as for other reasons stated to the employees in detail, the commission did not feel able to approve any

increase in pay or additional leave privileges for its hourly gold employees.

In general, the repair shops and the equipment on the Isthmus are adequate to meet all requirements and it is customary to provide for the fluctuating needs at the different points on the work either by transfers of machines between shops, or the transfer of work to the shop which has the best facilities for performing same.

A statement showing the distribution of tools in the various snops on the Isthmus at the close of the fiscal year is as follows:

60057°—10——14

List of tools and machinery on hand, by classes and location, as of July 1, 1910.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
LATHES.																
Iron-working:																
12-inch lathes		1		1		1			1	2				1		7
13-inch lathe			1													1
14-inch lathes	1		1			1				4					1	8
15-inch lathe															1	1
16-inch lathes		1	1			1				1					1	5
18-inch lathes		4	1		2	10	2	1		11			2	1		34
20-inch lathes		1		1												2
22-inch lathes			1							*a* 1						2
24-inch lathes	1	2	1			1				2			1		4	12
26-inch lathes		1													1	2
30-inch lathe															1	1
32-inch lathes			1			2										3
36-inch lathes	1		2	*a* 1		2				1					1	8
42-inch lathes		1				1									1	3
No. 2 turret lathe		1														1
Axle lathe		1														1
60-inch wheel lathe		1														1
48-inch wheel lathe		1														1
15-inch turret lathe			1													1
26-inch turret lathe			1													1
Turret lathe, 2 by 26 inch stock										1						1
Fox monitor turret lathe, No. 2						2										2
Universal turret lathe, No. 3						1										1
Double-head key lathe, 16-inch swing						1										1
Watchmaker's lathe						1										1
New model turret, 1¼ by 18 inch						1										1
Flat turret, 2¼ to 24 inch						1										1
Turret, 3 by 36 inch, 3 inches diameter						1										1
Axle lathes, No. 4, 11 foot 6 inch bed						2										2
Swing head axle lathe, No. 5, 13-foot bed						1										1
Steel-tire lathe, up to 42 inches diameter						1										1
Driving-wheel lathe, 66-inch drivers						1										1
Lathe bed, used as flue cutter, 14 foot						1										1
Engineer's instrument lathe, 24-inch bed						1										1
Toolmaker's lathe, 24-inch bed						1										1
79-inch wheel lathe						1										1

Turret lathe, 9 by 48 inch								1								1
Brass turret lathe, 18 inch										1						1
Iron turret lathe—																
3 by 36 inch stock										1						1
2-inch stock										1						1
Axle lathe, swing 20 inches over shears										1						1
Double spindle 26 by 48 inch lathe										1						1
64-inch wheel lathe, old French style										1						1
10-inch lathes															2	2
Big pit lathe															1	1
Engineer's precision lathe						1										1
Fox turret lathe, 18 inch		1														1
Wood-working:																
Turning lathe—																
12 foot 6 inch		1														1
Takes work to 6 feet		1														1
Buffing lathe, spindle 36 by 1½ inch		1														1
Lathe, 16 by 54 inch			1													1
Pattern maker's lathe—																
22 inch						1										1
24 inch						2										2
Pattern maker's speed lathe, 12 inch						1										1
Old French, 800-pound lathe											1					1
Turning lathe, H. & B.											1					1
20-inch lathes, old French style										2						2
30-inch turning lathe, old French style										1						1
Lathe, 10 by 48 inch														1		1
20-inch lathe															1	1
PLANERS.																
Iron-working:																
24-inch planers		2													1	3
26-inch planer						1										1
30-inch planers	1			1												2
32-inch planer		1														1
33-inch planers						2				2						4
36-inch planer		1														1
42-inch planers						2									1	3
48-inch planer										1						1
54-inch planer			1													1
Wood-working:																
4-roll planer and matcher		2				1										3
Machine wood planer, 16 by 84 inch						1										1
Pattern maker's planer, No. 3						1										1
Dimension planer, No. 32, 30 by 36 inch						1										1
Planer and matcher											1					1
Pony planer											1					1
18-inch planer												1				1
Small machine planer															1	1

a Old French style.

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
DRILLING MACHINES.																
11-inch drill						1										1
12-inch drill		1														1
14-inch drill		1				2										3
16-inch drill		1						1					1		1	4
18-inch drill		1	1													2
20-inch drill					1	4				1				1	1	8
21-inch drill		4														4
22-inch drill			2	1											1	4
23-inch drill	1					1				2						4
24-inch drill										3					1	4
26-inch drill						4		1		1						6
30-inch drill		1							2						1	4
31-inch drill						4							1			5
32-inch drill		1			1	1				2					1	6
33-inch drill										1						1
34-inch drill						1				2						3
36-inch drill				1										1	2	4
40-inch drill							1									1
42-inch drill					1											1
36-inch radial drill		1													1	2
5-foot radial drill press	1					1				1						3
Three-spindle drill, 26-inch reach		1								1						2
French radial press		1														1
Universal press, 8-foot radius			1													1
Universal press, 6-foot radius			1													1
Four-spindle drill						1										1
Universal press, 4-foot radius						1										1
Plain radial press, 66-inch						1										1
Radial press, 72-inch										1						1
Horizontal drilling machine, 18½-inch radius										1						1
Countersinking drill, 14-foot										1						1
Universal radial press, 5-foot radius										1						1
French drill, 1,800-pound											1					1
Radial drill, 7-foot radius													1			1
Portable drill															1	1
Wall press drill														1	1	2
Sensitive drill			1													1
Radial drill press															1	1

SHAPERS.																
Iron-working:																
8-inch shaper								1								1
11-inch shaper										1					1	2
12-inch shaper		1			1		1		1	1						5
16-inch shaper										1						1
18-inch shaper		1														1
20-inch shaper			1			1										2
21-inch shaper						1										1
22-inch shaper															1	1
24-inch shaper	1	2		1		2				3			1	1		11
32-inch shaper										1						1
36-inch shaper			1													1
Wood-working shaper											1					1
SAWING MACHINES.																
Iron-working:																
Q. & C. sawing machine, No. 115	1															1
14-inch power saw		1														1
Power hack saw, L. & C.		1														1
Cold saw		1								2						3
8-inch power hack saw			1													1
Higley cold steel saw, 26-inch			1													1
Band set saw			1													1
Power hack saw, 4½-inch				1												1
Power hack saw										2				1		3
Circular friction saw, 36-inch										1						1
Higley metal saw						1										1
Railway Appliance Co. metal saws						3										3
Rail saw															2	2
Wood-working:																
Car ripping saw, 4 by 8		1														1
Self-feeding rip saw, 4 by 7		1														1
Rip saw, 3 by 5		1														1
Rip saw, 2 feet 9 inches by 8 feet		1														1
Cut-off saw		1														1
Large automatic railway cut-off saw		1														1
Roller carriage cut-off saw		1														1
Scroll saw, flexible tension		1														1
Band saw machine—																
Wheels, 38-inch		1														1
Wheels, 30-inch		1														1
Wheels, 28-inch		1				1				1						3
Type 13						1										1
Band, rip, and resaw machine						1				1						2
Self-feeding band saw											1					1
Band saw, 26-inch												1				1
Frames band saw															2	2
Machine band saw, 36-inch											1					1
French band saw, 3-inch			1													1
Band saw, 1½-inch			1													1

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
SAWING MACHINES—continued.																
Wood-working—Continued.																
Automatic cut-off saw, 17 by 11, No. 11						1										1
Car rip saw, No. 4, 42-inch						1										1
Oliver swing cut-off saw, No. 36, 18-inch						1										1
Automatic railway cut-off saw										1						1
Swing saw, 30-inch										1						1
Jig saw											1					1
Rip saw											1	1				2
Rip saw, 14-inch												1				1
Circular table saw, table, 30-inch			1													1
Frames circular saws															3	3
Automatic feed rip saw										1						1
Circular saws												2				2
BORING MILLS.																
Iron-working:																
Horizontal mill		1														1
Horizontal mill, 5 feet 6 inches by 8 feet			1													1
Horizontal boring, drilling, and milling						1										1
Horizontal boring and drilling, No. 2						1										1
Horizontal mill—																
24-inch										1						1
16-foot										1						1
Vertical mill—																
36-inch		1														1
7 by 4 feet 6 inches			1													1
8 by 12 feet			1													1
Vertical boring and turning—																
37-inch						1										1
51-inch						1										1
96-inch						1										1
Vertical mill—																
10 by 16 feet										1						1
38-inch maximum swing										1						1
Vertical boring and turning, 38-inch maximum										1						1
Wheel-boring mill		2				1										3
Boring machine for dredge buckets			1													1

Cylinder-boring machine and bar		1														1
Portable boring bar, 4½-inch			1													1
Portable cylinder-boring machine						1										1
10 by 24 by 60										1						1
4 by 12 by 30										1						1
72-inch boring mill															1	1
Wood-working:																
3-spindle car borer, $\frac{7}{16}$ to 2-inch bits		1								1						2
1-spindle horizontal boring mill		1														1
Horizontal wood-boring mill						1										1
Vertical boring mill, up to 3 inches										1						1
Post-boring mill, Hamilton No. 1												1				1
Vertical mill, 24-inch													1			1
SLOTTERS.																
Crank slotter, 10-inch						1										1
Slotter:																
14-inch		1														1
15-inch										1						1
40 by 60 by 16 inches			1													1
Crank slotter, 26-inch						1										1
Slotter:																
30-inch		1														1
36-inch															1	1
72-inch															1	1
CENTERING MACHINES.																
Centering machine		1														1
2-spindle centering machine										2						2
Centering machine, 8 inches by 4 feet						1										1
PUNCH AND SHEARS.																
Punch and shears, No. 3, 36-inch	1		1													2
Hand punch, 1 inch in ½-inch plate										1						1
Punch and shears		1									1				1	3
Punch and shears, No. 305		1														1
Small punch and shears		2														2
Double-end punch			1													1
Punch and shears, H. & J., No. 2, 36-inch throat			1							1						2
Angle and round iron shears			1													1
Lennox splitting shears			1			1										2
Single-end punch and shears, 120-inch			1													1
Single punch and shears					1											1
Single punch and shears, Bouhey:																
No. 4						1										1
No. 5						1										1
No. 1						1										1
No. 3															1	1

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
PUNCH AND SHEARS—continued.																
Rapid-acting single punch						1										1
Splitting shears						1										1
Bar-iron shears						1										1
Rotary splitting shears, 7-foot										1						1
Punch and shears, ½ by 3-inch flat-bar maximum										a 1						1
Double punch and shears, 14-inch													1			1
Single shears, D 22														1		1
Single punch, No. 5														1		1
Punch and angle-iron shears															1	1
Power punch															1	1
Power shears															1	1
Shears, 36-inch bite			1													1
Horizontal punch, H. & J., No. 2			1													1
Punch, No. 18			1													1
Machine punch, 24-inch throat						4										4
Bouhey shears, 42-inch			1													1
MILLING MACHINES.																
No. 3 Hendy Norton, Universal		1								1						2
Le Blond, 2¼ by 28 by 8 by 19 inches				1												1
Universal, No. 2, 24 by 7½ by 18 inches						1										1
Universal No. 3			1			2									1	4
Hand milling machine, No. 2										1						1
Milling machine—																
24 by 27½ by 16 inches										1						1
No. 3										1						1
TOOL SHARPENERS.																
Grindstone:																
6 by 48 inches, old French style									1	2						3
6 by 48 inches	1									2				1		4
Grindstone base		1														1
Grindstone:																
8 by 48 inches		1														1
6 by 36 inches										1						1
6 by 54 inches				1												1

Power grindstone:																
8 by 29 inches					1											1
8 by 48 inches								1								1
Grindstone, 36 inches			1													1
Grindstone, 4 by 24 inches										1						1
Emery wheel machine, 2 wheels, 1 by 14 inches and 1 by 15 inches	1															1
Emery wheel frame, 14 inches		1														1
Emery wheels		1	3													4
Washburn emery wheel			1													1
Emery grinder:																
No. 2½			1													1
No. 3			1													1
2 by 14 inches				1						2						3
Emery drill grinder, ⅛ inch to 2¼ inches				1												1
Emery wheel:																
12-inch									1	1			1			3
16-inch										3						3
2 by 16 inches										1						1
Emery wheel frame, old French style															1	1
New Yankee drill grinder, wet and dry	1															1
Ajax drill sharpener	1															1
No. 2 Universal Oesterlein grinder		1		1		1										3
Cold saw grinder		1														1
American twist drill grinder		1				1										2
Barnes wet tool grinder		1														1
Automatic knife-grinding machine		1									1					2
Higley saw grinder, No. 7			1													1
Automatic saw grinder						1									1	2
Open side automatic surface grinder						1										1
Automatic saw grinder:																
28-inch saws						1										1
8-inch to 48-inch saws						1										1
Planer knife grinder, 24-inch knives						1										1
Horizontal automatic knife grinder, 36-inch knives						1										1
Wet tool grinder:																
2½ by 14 inches						1				1						2
2½ by 26 inches						1										1
2 by 26 inches						1		1								2
Combination wet and dry grinder, No. 2						3										3
Valley City dry grinder, No. 14						2										2
Double dry grinder, 4 by 16 inches						2										2
Universal friction drive grinder						1										1
Patternmaker's disk grinder						1										1
File-sharpening machine						1				1						2
Double bench grinder, 12-inch and 16-inch										1						1
Circular saw sharpener, 36-inch										1						1
Band saw sharpener and grinder										1						1
Grinding machine, 36 by 42 inches, old French planer										1						1

a Old French style.

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
TOOL SHARPENERS—continued.																
Planer knife grinder, 44-inch										1						1
Cold saw grinder, 36-inch, Higley										2						2
Band saw filing machine						1				1						2
Combination automatic circular saw and hand cross-cut sharpener, 40-inch capacity			1													1
6-inch cutter and reamer grinder, ⅓ inch to 3½ inches, Oesterlein										1						1
American twist drill grinder, ⅛ inch to 3½ inches										1						1
Knife-grinding machine											1					1
Automatic saw grinder											1					1
Knife grinder												2				2
Tool grinder, No. 7														1		1
Machine emery grinder															1	1
Machine grinder															1	1
Universal tool grinder, 18-inch			1													1
Yankee drill grinder			1													1
Machine combination wet and dry grinder													1			1
Band saw setter										1						1
Miscellaneous grindstones		2														2
Wet grinder		1														1
Wet grinder, 16-inch		1														1
Universal grinder		1														1
PIPE MACHINES.																
Pipe-threading machine, 2-inch					1	3										4
Pipe-threading machine		1														1
Pipe machine, 4-inch															1	1
Pipe cutting and threading machine, 6-inch	1	1	2	1		1				1			1		1	9
Pipe machine:																
8-inch														1	2	3
10-inch						1										1
12-inch		1	1							1			1			4
Large hand power pipe machine, 12-inch	1															1
Pipe-bending machine, 2-inch						2				1			1			4
Pipe machine															1	1

Pipe and bolt threading machine															1	1
Pipe cutting-off machine										1						1
Pipe-bending machine								1								1
BOLT MACHINES.																
Double head bolt cutter, ½-inch						1										1
Bolt cutter:																
1½-inch			1			4										5
2-inch		1		1		4				1			1			8
Double head bolt cutter		2														2
Triple head bolt cutter		1														1
Bolt-heading machine		1														1
Bolt heading, upsetting, etc., machine						1										1
Bolt cutter, 3-inch, single head										1						1
Bolt cutter:																
3½-inch														1		1
2½-inch	1															1
MORTISING MACHINES.																
Vertical machine, with boring attachment		1														1
Vertical hollow chisel, ¾-inch to 2-inch attachment		1								1						2
Mortising and boring machine, ½ by 3 by 24			1													1
Mortising and boring machine											1					1
Chain mortiser											1					1
Blind mortising and boring machine											1					1
Vertical mortiser:																
No. 2, ¾-inch						1										1
No. 4, 1½-inch						1										1
NUT MACHINES, ETC.																
Spindle nut tapper, ½ by 1½ inches		1														1
Rivet bolt and upsetting machine			1													1
Nut tapper, to 2-inch nuts						1										1
Nut and bolt machine															1	1
U-bolt bender										1						1
Bolt-forging machine															1	1
COUNTERSINKING MACHINES.																
Radial countersink, 15-foot radius			1													1
Old French countersink															1	1
VALVE MACHINES.																
Valve seat facing machine		2								1						3
Portable valve reseating machine						1				1						2
Valve-testing machine							1									1
Valve-seating machine								2								2

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

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FLANGING CLAMPS.																
Flanging clamps:																
6-foot						2										2
8-foot	1															1
10-foot			1													1
12-foot						1				1						2
Large clamps		1														1
ROLLERS.																
1-inch		9														9
1¾-inch		5														5
2-inch		15														15
2½-inch		3														3
3-inch		3														3
3½-inch		2														2
4-inch		1														1
5-inch		1														1
12-foot by 12-inch		1				1										2
36-inch			1													1
5-foot										1						1
6-foot						1				1						2
10-foot			1													1
12-foot			1							1						2
Small rollers		1														1
Hand rollers		1														1
Power roll plate machine															1	1
Hand roll plate machine															1	1
Horizontal jeweler's rolls, 4 by 3 inches						1										1
MISCELLANEOUS IRON-WORKING MACHINES.																
Press for straightening sheet iron						1										1
Spur-geared foundry tumblers:																
24 by 36 inches						1										1
42 by 72 inches						2										2
McGrath flue-welding machine						1										1
Boiler flue cleaning apparatus						1										1
Core machine in foundry						1										1
Tube cutter, O'Neil, No. 1						2										2
Flue-welding furnace						1				1						2

Casting breaking device						1										1
Magnetic separator						1										1
Journal brass babbitting machine						1										1
Fly wheel sprue cutter, $1\frac{1}{8}$ by $\frac{1}{2}$ by $1\frac{3}{4}$						1										1
Gasoline portable tire heater						1										1
Vertical shaft Gatlin keyseater, No. 3						1										1
Machine press for straightening car apron						1										1
2-inch sectional beading expanders		18														18
Pneumatic tube welder		1														1
Chain and sprocket tube cleaner		1														1
Bending and angle machine, 100 tons capacity										1						1
Squeeze riveter										1						1
Bar cutter										1						1
Portable cylinder facing machine, 19 inches to 20 inches										1						1
Bulldozing and shackle bending machine															1	1
Riveting machine															1	1
Chicago pneumatic bull riveter			1													1
Yoke riveter															1	1
MISCELLANEOUS WOOD-WORKING MACHINES.																
Car graining machine						2										2
6-roller double-cylinder timber sizer		1														1
6-inch sticker or molding machine		1														1
Single surfacer, 12 by 24 inch			1													1
Car-sill tenoner						1										1
Universal jointer						1										1
Universal wood worker						1										1
4-side sizer						1										1
Universal saw bench						1										1
Combination saw table						1										1
Universal wood trimmer:																
No. 4 E						1										1
No. 4 F						1										1
Jointer, 24-inch										1						1
Timber sizer, 24 feet wide by 14 inches high										1						1
Tenoner											2					2
Blind wiring machine											3					3
Jointer, 12-inch													1			1
Jumper, complete, old French style											1					1
Molding machine											1					1
Sand-papering machine											1					1
Sash ticker											1					1
Sash and door clamp											1					1
Woodworker											1					1
Saw table, old French style, 1,200-pound											1					1
Saw setting and filing apparatus												1				1
Hamilton cut-off machine, 13-foot table												1				1
Car sill and timber dressing machine															1	1
Air-driven machine		1														1

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

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TINNER'S TOOLS.																
Universal folder and brake:																
42-inch						1										1
38-inch						1										1
Large burr, encased						1										1
Small burr, encased						1										1
Small encased turner						1										1
Large encased turner						1										1
Extra small encased turner						1										1
Wiring machine						1										1
Setting-down machine:																
Small, encased						1										1
Extra heavy						1										1
Beader:																
No. 4						1										1
No. 2						1										1
Cornice-maker's crimper						1										1
Groover:																
No. 2, 20-inch						1										1
No. 2, 36-inch						1										1
Funnel former, 10-inch rolls						1										1
Slip roll former, 36 by 2 inches						1										1
Circle shears, No. 22						1										1
Spurring shears:																
36-inch stroke						1										1
15-inch stroke						1										1
Squaring shears, heavy						1										1
Lever punch, No. 44						1										1
Wire straightener, $\frac{1}{8}$ to $\frac{1}{4}$ inch						1										1
Candle-mold stake, $8\frac{1}{2}$-inch horn						1										1
Creasing stake, $9\frac{1}{2}$-inch end						1										1
Beak horn stake, No. 1						1										1
Blow horn stake, $17\frac{1}{2}$ inches by 9 feet						1										1
Bevel edge square stake, 3 by 5 inches						1										1
Needle-case stake, 8 by $8\frac{1}{2}$ inches						1										1
Double-seaming stake, 17 by 12						1										1
Squaring stake, $2\frac{3}{8}$ by $4\frac{1}{2}$ inches						1										1
Bottom stake, No. 1						1										1
Hatchet stake, No. 1, 16-inch						3										3

Creasing stake with horn, 9½ by 6½						1										1
Double-seaming stake						1										1
Round-head stake						1										1
Hollow mandrel stake						1										1
Crimper and bender, 6-inch										1						1
Turning machine, small										1						1
Setting-down machine										1						1
Turning machine, large										1						1
Wiring machine										1						1
Square shears, 36-inch										1						1
Folder, 3 feet 6 inches										1						1
Tin folding machine, 30-inch										1						1
Groover, 36-inch										1						1
Sheet-iron folder, 30-inch										1						1
Elbow-closing machine										1						1
Bench roll, 36-inch										1						1
Burring machine:																
Large										1						1
Small										1						1
Tinner's rolls, 20-inch										1						1
Folding machine, 42-inch			1													1
POWER HAMMERS.																
Air hammer, 50-pound														1		1
Bradley helve, 100-pound						2				1						3
Air hammer, 150-pound															1	1
Bradley helve, 200-pound						1										1
Power hammer, 300-pound										1						1
Steam hammer:																
600-pound						1				1						2
800-pound			1	1	1	1										4
1,100-pound															1	1
1,200-pound	1															1
2,000-pound						1										1
2,500-pound			1							1						2
Air hammer		24														24
Steam hammer (no weight)		2														2
Bradley hammer		1														1
Steam hammer, 2,700-pound						1										1
HYDRAULIC PRESSES.																
Hydraulic press:																
48-inch		1														1
100-ton			1													1
Hydrostatic press, 30-ton					1			1		1			1			4
Hydraulic horizontal wheel press:																
36-inch, 100-ton						1										1
48-inch, 200-ton						1										1
66-inch, 200-ton						1										1
Hydrostatic press, 78-inch, 300-ton										1						1

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CRANK-PIN PRESSES.																
150-ton adjustable, $3\frac{3}{4}$ by $1\frac{1}{2}$ piston	1															1
Crank pin turning machine		1														1
ARBOR PRESSES.																
Arbor press:																
No. $3\frac{1}{2}$, 3-inch mandrel						3										3
No. 5, $4\frac{1}{2}$-inch mandrel						1										1
12-inch, Greenard No. 3										1						1
22-inch, Greenard No. $3\frac{3}{4}$										2						2
CRANES AND HOISTS.																
$\frac{1}{2}$ ton:																
Jib crane—																
14-foot radius						1										1
15-foot radius						1										1
Jib pneumatic hoist, 22-foot radius						1										1
Tram pneumatic hoist, 35-foot beam						1										1
1-ton:																
Jib pneumatic hoist—																
15-foot radius						1										1
14-foot radius						1										1
Pneumatic jib crane, 15-foot radius						1										1
Jib crane—																
13-foot radius						3										3
18-foot radius						2										2
11-foot radius						1										1
Top-braced, 18-foot radius						1										1
Tram crane—																
50 foot radius						1										1
30-foot radius						1										1
Cylindrical pneumatic jib, 18-foot radius						1										1
Portable crane			2													2
Trolley crane			1			1										2
Franklin portable crane						8				3						11
$1\frac{1}{2}$-ton jib crane										1						1

2-ton:																
I-beam trolley crane			2													8
Jib crane			12			6										12
Stationary crane			1													1
Electric crane			1													1
Franklin portable crane						1										1
Pneumatic hoist and jib crane						1										1
Post-jib crane, 13-foot radius						1										1
Pneumatic hoist, 18-foot radius						2										2
Jib crane—																
24-foot radius						2										2
13-foot radius						2										2
Jib chain-fall hoist						1									1	2
Post crane										4						4
3-ton:																
Portable crane			1													1
Air hoist			2													2
Pneumatic hoist—																
18-foot radius						1										1
15-foot radius						1										1
Car-loading hoist, 15-foot radius						1										1
Jib crane, 15-foot radius						1				5						6
Franklin portable crane						2				2						4
4-ton air hoist															1	1
5-ton jib crane, over squeeze rivet										1						1
10-ton:																
Electric traveling crane						1				1						2
Pneumatic hoist						3										3
20-ton electric crane										2						2
½-ton jib crane, 13-foot radius						1										1
2-A Franklin portable crane										1						1
A Franklin portable crane										1						1
Post crane										1						1
8-ton swinging crane		2														2
Wheel jib crane, 14-foot radius	1															1
5-ton overhead track crane	1															1
Cable hoist								1								1
SCALES.																
100-ton track scales										1						1
9,000-pound platform scales										1						1
FORGES AND FURNACES.																
Forge:																
4-foot diameter	5			5												10
4 by 8 feet	1															1
Furnace, No. 8	1															1
Large forge		5														5
Air-rivet forge		11		2												13
Hand-rivet forge		1														1
Portable blacksmith forge		1		1												2

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List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

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FORGES AND FURNACES—continued.																
Foundry cupola:																
48-inch						1										1
42-inch						1										1
Double blacksmith's forge:																
46 by 96 by 26						1										1
46 by 96 by 24						3										3
Single blacksmith's forge:																
48-inch						13										13
65-inch						1										1
Single coppersmith's forge:																
48-inch						1										1
60-inch						1										1
Portable forge:																
36 by 60 by 14						1										1
44 by 72 by 24						1										1
Furnace:																
Class N, Calorex						1										1
Class D, Calorex						1										1
Class G-8, Calorex						1										1
Class D-2, Calorex						1										1
Class F-420, Calorex						1										1
Class F-372 Calorex						1										1
Class F-80, Calorex						1										1
Class B, Calorex						1										1
Annealing furnace						1										1
Bolt furnace:																
1-inch bolts, 21 by 36 by 48						1										1
2-inch bolts, 24 by 48 by 50						1										1
Heating furnace, 38 by 46 by 108						1										1
Bolt-heating furnace, 30 by 34 by 12						1										1
Journal brasses furnace						1										1
Soft-coal scrap furnace						1										1
Furnace for No. 60 steel Harvey crucible						1										1
Furnace for No. 150 steel Harvey crucible						2										2
Portable rivet forge											1					1

Oil furnace:																
5 by 5 by 3 feet															1	1
4 by 2 by 2½ feet															1	1
4 feet by 18 inches by 18 inches															1	1
3½ feet by 1 foot 8 inches by 1 foot 8 inches															1	1
Oil furnace															1	1
BLOWERS.																
18-inch Sturtevant	1	1														2
Forge fan:																
Old French style				1	1										1	3
Sturtevant No. 8			2			2				1						5
Root cupola blower, No. 4						2										2
Fan blower, 36-inch													2			2
Blower, 35-inch									1							1
Blower		1													1	2
PUMPS.																
Pump, 10 by 6 by 10		2	1													3
Compound, Westinghouse		1														1
Westinghouse, 12 by 8½ by 10		1														1
Blake, 10 by 16 by 14		1														1
Worthington, 3-inch suction, 2-inch discharge		1														1
Blake & Know feed pump			1													1
Centrifugal pump			2													2
Lift pump			1													1
Feed pump			1													1
Portable boiler test pump						1										1
Boiler test pump						1										1
Duplex Dean pump								1								1
Boiler test pump										1						1
Boiler test pump, 1¾ by 4										1						1
Dean pump, 12½ by 2¾ by 12										1						1
Steam pump, old French style, 3½ by 4													1			1
Portable boiler test pump, 2½-inch	1															1
Blake pump, 4½ by 2¾ by 4				1												1
Knoles pump, 16 by 10 by 19				1												1
Pump, old French style, 400-pound											1					1
BOILERS.																
Upright boiler, 35-horsepower													1			1
Stationary boiler, 65-horsepower		2														2
Shop boiler			2													2
Scotch marine boiler			1	2												3
Boilers, miscellaneous										1	2					3

List of tools and machinery on hand, by classes and location, as of July 1, 1910—Continued.

	Porto Bello shops.	Cristobal shops, Panama R. R.	Cristobal dry dock.	Gatun machine shop.	Tabernilla engine house.	Gorgona shops.	Gamboa engine house.	Las Cascadas engine house.	Bas Obispo shop.	Empire shops.	Lirio planing mill.	Pedro Miguel planing mill.	Pedro Miguel engine house.	Miraflores shop (Cocoli).	Balboa shop.	Total.
ENGINES.																
French compound stationary		1														1
Blower engine, 10 by 10 inches		1														1
Stationary engines		2													1	3
Portland stationary engine		1														1
Engine			1													1
Engine, old French style, 25-horsepower					1											1
Engine, upright, old French style, 10-horsepower					1											1
Horizontal marine, old French style, 52-horsepower					2											2
Engine, 2-cylinder, vertical								1								1
Double-cylinder horizontal engine								1								1
Double vertical, old French style, 30 horsepower									1							1
Marine engine, old French style, 30-horsepower										1						1
Hoisting engine, 2-cylinder, 7 by 10 inches										1						1
Vertical engine, 2-cylinder										1						1
Nagle engine, 100-horsepower											1					1
Hoisting engine, 8 by 12 inches													1			1
Auxiliary engine			1													1
MOTORS.																
Pneumatic motor, with pulley, 2-horsepower						1							1			2
Induction motor, 5-horsepower										1						1
Electric motor, 10-horsepower													1			1
Motors, 15-horsepower			1										1			2
Direct current, 15-horsepower, 115-volt, 625 revolutions per minute	2															2
Electric motor, 30-horsepower				1						3						4
Induction motor:																
35-horsepower										1						1
37-horsepower										1						1
Electric motor, 50-horsepower										2						2
Pneumatic motor, opposed								2								2
Motor, 75-horsepower															2	2

GENERATORS.																
10-kilowatt			1													1
13-kilowatt			1													1
20-kilowatt			1													1
AIR COMPRESSORS.																
800 cubic feet, 100-pound pressure			1													1
1,200 cubic feet, 100-pound pressure			1													1
Type 10 compressor		2														2
Compound compressor															1	1
New York locomotive air pump				3												3
GAUGE-TESTING MACHINES.																
Gauge-testing machine, 300-pound						1										1
Gauge-testing machine								1								1
MISCELLANEOUS.																
Portable air-brake-testing machine													1			1
Air-hose machine						1										1
Portable sand sifter						1										1
Paint-grinding machine						1										1
Belt-lacing machine, 12-inch belts						1										1
Eureka paint sprayer						2										2
Anvils:																
300-pound	5															5
150-pound				6												6
Swage blocks	2			1												3
Face plates, 5 by 5 feet	2			1												3
Air-storage tank			1	1												2
Steam glue heater						1										1
Molding machines, 24-inch						2										2

While a large percentage of the shop tools are of American manufacture, such of the old French machinery and tools as is serviceable has been continued in use. The four principal shops on the Isthmus, located at Gorgona, Empire, Cristobal, and Balboa, are the successors of old, small shops taken over from the French company upon American occupation.

No attempt has been made to provide for permanent shop facilities for use after the completion of the canal. The general views of the commission on this matter are expressed in resolution of the commission, adopted at its one hundred and fifty-sixth meeting, held at Culebra, Canal Zone, on April 23, 1910, reading as follows:

Upon motion, it was—

Resolved, That economy in the administration of the Panama Canal, both before and after completion, requires adherence to the principle that such facilities, appurtenances, etc., as may be required for its construction, sanitation, operation, maintenance, repair, defense, and commercial use, and by the Panama Railroad Company and by the Canal Zone government, shall be combined and consolidated, so far as practicable, without duplication, regardless of their use by more than one executive department of the Government.

This policy, if adhered to, will limit the permanent shop facilities to two points, one near each end of the canal, equipped so as to meet all requirements of the United States in connection with the maintenance, operation, and protection of the canal, including the needs of the Panama Railroad Company, as well as those arising from the commercial use of the canal.

During the year special attention has been paid to reducing the cost of maintenance and operation of the equipment and shops, salaries and wages have been standardized, and the use of material and supplies necessary in operation and repairs made more uniform.

In line with this policy, in the early part of the fiscal year two traveling engineers were appointed to instruct engineers, firemen, and hostlers in all divisions in regard to the proper operation of locomotives and economy in the use of fuel and oil. No repairs to locomotives are made without their passing on the necessity thereof and approving same. Their work along these lines being satisfactory, their jurisdiction was afterwards extended to cover locomotives of the Panama Railroad Company, with very satisfactory results. Locomotives have been placed on a daily allowance of lubricating oils, etc., and close supervision thereof exercised, which has resulted in a saving of lubricants of fully 50 per cent. A marked economy in fuel consumption has likewise been attained by instructing firemen, by requiring a higher standard of applicants for the position of fireman, by preventing loss of steam through safety valves, by enforcing firing by improved methods, by increasing the train load, etc. The coal consumption per train mile has been reduced approximately 10 per cent.

The total cost of repairs to equipment in continuous service and the cost per service day for the six months ended June 30, 1910, is as follows:

Item of equipment.	Service days.	Total expense.	Average cost per service day.
Locomotives	31,955	$221,760.01	$6.94
Steam shovels	9,527	263,550.54	27.66
Unloaders	1,655	34,015.34	20.55
Spreaders	1,127	19,496.48	17.30
Track shifters	798	5,326.12	6.67
Locomotive cranes	3,075	11,684.20	3.80
Pile drivers	442	4,165.78	9.42
Unloading plows	1,655	6,267.61	3.79

The total cost of repairs to cars of all classes for the same period has been $479,165.75, or an average of $1.03 per car per working day.

Electric current for lighting and power is generated at five stations on the Isthmus, located at Balboa, Empire, Miraflores, Gorgona, and Gatun. The current generated and the cost per kilowatt hour delivered for each plant for the six months ended June 30, 1910, is as follows:

Cost of electric current for six months ended June 30, 1910.

Location of plant.	Kilowatt hours.	Expenses.	Cost per kilowatt hour.
Balboa [a]	642,645	$28,006.70	$0.0421
Empire [a]	1,190,070	35,692.65	.0299
Gorgona [a]	336,779	13,160.78	.0391
Miraflores [b]	543,595	33,830.83	.0622
Gatun [c]	4,314,586	112,269.04	.0260
Total	7,027,675	222,960.00	.0317

[a] Original cost of these plants has been charged to divisions on basis of benefits received. The product is invoiced to the departments and divisions at a price that provides for renewals and new machinery.
[b] Includes $0.0090 per kilowatt hour to absorb cost of plant.
[c] Includes $0.0088 per kilowatt hour to absorb cost of plant.

While the cost of repairs per service day for locomotives compares very favorably with the amounts paid by railroads in the United States for similar work, it must be remembered that the monthly locomotive mileage on the Isthmus is less than one-half the average monthly locomotive mileage in the United States and the cost of repairs per mile on the Isthmus is, therefore, correspondingly greater. One reason for this difference is the fact that the average wages of gold mechanics on the Isthmus are over 50 per cent greater than the pay of mechanics in the United States.

For the six months ended June 30, 1910, the average cost of repairs to plant and equipment per unit of work accomplished was as follows:

Item of work.	Amount of work accomplished.	Total cost of repairs.	Average cost of repairs per unit.
Excavation:	*Cubic yards.*		
Dry	10,515,443	$835,854.00	$0.0795
Wet	5,274,633	377,052.48	.0715
Concrete	565,459	98,423.59	.1741
Sand	316,028	88,139.70	.2789
Stone	581,812	140,223.25	.2410
Fill:			
Dry	1,913,963	12,471.92	.0065
Wet	1,556,745	91,319.78	.0587

The cost of hostling locomotives has been reduced one-third and averages now approximately $1 per night for labor, and the standard of efficiency required for hostlers has been raised.

The maximum pay of silver locomotive firemen has been reduced from $60 to $50 per month and the efficiency of all firemen meanwhile increased. Spaniards have been employed in competition with West Indians with satisfactory results.

On April 29, 1910, the position of inspector of shops was established in connection with the inspection of the different electrical and mechanical shops of the commission and Panama Railroad, including the economical distribution of tools, machinery and work among them, the adoption of standard shop methods, the furnishing of additional shop facilities, etc.

The principal change in the shop organization during the year was the transfer of the Empire shops from the mechanical to the central division, involving combining all steam-shovel general repair work at the Empire shops, and the transfer from Empire shops to the Gorgona shops of steel-car repair work. This change enabled the mechanical division to concentrate its supervisory forces at Gorgona under a superintendent, to abolish its Culebra office, and to reduce its overhead charges. The net saving per annum resulting from this change amounts to over $100,000.

Further changes in the organizations charged with responsibility of keeping machinery, plant, and equipment in efficient condition in the most economical manner will be made as their necessity develops during the progress of the work.

During the latter part of the fiscal year the position of traveling engineer in connection with the inspection of all fuel and oil consumption (except on locomotives and marine equipment), including the instruction of employees in the economical use of fuel and oil and the satisfactory performance of all firemen, was established. The opportunity to effect large savings along these lines can be appreciated from a statement of the amount and cost of fuel and oil used annually on the Isthmus, which, including the Panama Railroad Company, is as follows:

Coal .... tons..	398,720
Fuel oil .... barrels..	650,000
Lubricating oils, etc	$136,000

All expenditures on account of construction work and plant are classified under certain subaccounts, which, as printed in the last annual report, remained in effect, with certain slight changes and modifications necessary to bring them up to date.

Effective July 1, 1909, the subaccounts of the department of construction and engineering were divided into (*a*) construction work, and (*b*) plant, and plant arbitraries were established as the basis for construction work absorbing monthly the proper proportion of charges for plant, the arbitraries being so fixed, and subject to readjustment at periods not exceeding one year, as to cause the plant charges to be completely absorbed upon the completion of the work.

In compiling for each division, under each subaccount, the unit costs of work, to the "division cost" are added, in order to arrive at the total unit cost, the following:

1. Plant arbitrary.

2. Proper proportion of the expenses of the office of the chief engineer, and other general engineering expenses, which are classed as "General administrative expenses."

3. Proper proportion of the "General expenses" of the commission, including miscellaneous general expenses, expenses of the quartermaster's and subsistence departments, expenses of the offices of the examiner of accounts and disbursing officer, etc.

The sum of these items represents the total unit cost.

The following statement shows the details of expenditures for plant to June 30, 1909, and for the fiscal year 1910; the absorption of plant charges by construction work to date; and balances remaining in plant which are to be absorbed in the future:

Item.	Charges to June 30, 1909.	Charged during year.	Arbitrary—absorbed during year.	Plant to be absorbed to end of work.
ATLANTIC DIVISION.				
Dry excavation	$196,507.74	$9,763.99	$155,656.93	$50,614.80
Dredging excavation	1,711,184.35	306,187.66	1,120,982.20	896,389.81
Gatun Dam and spillway	826,794.83	117,141.54	701,929.62	242,006.75
Gatun locks	1,057,054.39	947,060.82	802,473.88	1,201,641.33
Gatun power plant	194,462.88	....	....	194,462.88
Porto Bello quarry	996,834.43	56,480.22	235,009.10	818,305.55
Nombre de Dios, sand	235,973.20	160,088.80	69,641.48	326,420.52
Transportation	1,150,882.08	363,509.48	348,506.22	1,165,885.34
Colon breakwater	326,969.71	122,210.00	....	449,179.71
CENTRAL DIVISION.				
Dry excavation	10,589,005.30	[a] **101,412.26**	7,646,020.58	2,841,572.46
PACIFIC DIVISION.				
Dry excavation	282,510.01	19,999.47	23,401.26	279,108.22
Dredging excavation	2,244,385.70	597,832.22	2,146,332.61	695,885.31
Pedro Miguel locks and dams	323,551.00	479,830.19	184,147.79	619,233.40
Miraflores locks and dams	465,869.06	460,729.49	240,526.90	686,071.65
Ancon quarry	327,914.15	441,043.87	59,559.16	709,398.86
Chame sand	162,105.52	133,352.07	40,661.02	254,796.57
Miraflores power plant	218,934.91	274,693.99	7,532.08	486,096.82
Total	21,310,939.26	4,388,511.55	13,782,380.83	11,917,069.98

[a] Indicates credit—equipment transferred to other divisions.

The total amount and distribution of "General administrative expenses" and "General expenses" of the commission during the fiscal year to the three construction divisions, the departments of civil administration and sanitation, and the work of building the relocated Panama Railroad, is as follows:

Distribution of general administrative expense and of general expenses for eleven months, July, 1909, to May, 1910, inclusive.

	Total.	Atlantic division.	Central division.	Pacific division.	Civil administration.	Sanitation.	Relocation of Panama R. R.
General administrative expenses [a]	$258,819.73	$101,404.46	$78,198.75	$79,216.52	....	....	....
Miscellaneous general expenses:							
On Isthmus [b]	79,197.20	18,674.14	33,394.65	12,117.41	$3,142.90	$6,540.66	$557.84 4,769.60
Canal Record [c]	18,398.34	4,395.63	7,672.82	2,739.93	932.56	1,503.00	45.60 1,108.80
Young Men's Christian Association clubhouses [c]	38,812.41	10,136.23	17,466.31	4,654.53	1,900.99	2,254.59	153.12 2,246.64
Isthmian Canal Commission band [b]	11,393.39	2,703.12	4,826.33	1,749.98	453.14	942.42	43.44 674.96
In United States [b]	108,165.90	26,478.20	49,772.65	17,634.65	4,634.15	9,646.25	....
Disbursing officers:							
In Washington [b]	30,751.90	7,804.69	13,840.33	5,084.85	1,313.01	2,709.02	....
On Isthmus [b]	70,169.07	17,731.65	31,700.47	11,523.91	3,000.66	6,212.38	....
Examiner of accounts:							
In Washington [b]	10,516.68	2,678.32	4,735.74	1,724.98	449.84	927.80	....
On Isthmus [b]	163,637.91	41,407.43	73,874.70	26,866.67	7,004.90	14,484.21	....
Transportation on Isthmus (passenger) [c]	121,000.00	31,297.96	53,084.86	19,399.02	6,769.76	10,448.40	....
Telegraph and telephones [d]	126,896.42	32,042.67	64,527.14	13,191.28	8,143.91	8,991.42	....
Purchasing expense in the United States [e]	160,702.97	61,611.30	49,372.47	41,233.69	846.47	7,639.04	....
Hotels, messes, and kitchens (operations) [c]	[f] 28,358.27	[f] 7,895.88	[f] 11,826.21	[f] 4,617.13	[f] 1,709.36	[f] 2,309.69	....
Hotel equipment [c]	19,213.46	5,025.99	8,341.16	3,100.48	1,107.77	1,638.06	....
Hotel, incidental expenses [c]	25,791.61	6,639.68	11,327.24	4,140.12	1,435.74	2,248.83	....
Tivoli Hotel [c]	[f] 4,598.77	[f] 1,891.78	[f] 1,062.12	[f] 864.16	[f] 527.02	[f] 253.69	....
Operation of stores [e]	380,913.03	140,164.45	129,839.80	89,149.09	2,245.30	19,514.39	....
Freight, advertising, and miscellaneous items [e]	92,710.07	34,358.77	27,716.68	25,542.53	402.25	4,689.84	....
Recruiting [b]	133,637.47	31,986.28	55,187.63	21,118.03	5,544.00	11,301.53	8,500.00
Quarters [b]	510,067.76	128,944.22	230,405.68	83,627.21	21,893.04	45,197.61	....
Corrals:							
Equipment [b]	42,180.98	11,164.65	18,204.53	6,872.11	1,975.32	3,964.37	....
Operation [b]	64,726.77	16,074.09	29,623.12	10,480.57	2,765.23	5,783.76	....
Total	2,434,746.03	722,936.27	980,224.73	475,686.27	73,724.56	164,074.20	18,100.00

DIRECT DIVISION COSTS.

Transportation on Isthmus (freight)[g]	$665,098.33	$170,787.46	$306,463.40	$178,847.47		$9,000.00	
Compensation to injured employees[h]	163,830.05	36,280.67	97,390.43	27,119.69	$1,947.41	1,091.85	
Total	828,928.38	207,068.13	403,853.83	205,967.16	1,947.41	10,091.85	

[a] Prorated on basis of total expenses of the three construction divisions, excepting amounts which can be definitely located to the work.
[b] Prorated on basis of total salaries and wages charges to expenditures, excepting proportion of general expenses on the Isthmus and of the Isthmian Canal Commission band, charged to relocation.
[c] Prorated on basis of pay rolls for gold employees, excepting proportion of general expenses of the Canal Record and Young Men's Christian Association clubhouses, charged to relocation.
[d] Prorated on basis of benefits received.
[e] Prorated on basis of total expenditures charges for material and supplies, less rock and sand.
[f] Indicates credit.
[g] Prorated on basis of actual freight handled.
[h] Prorated on actual basis.

NOTE.—The month of June, 1910, is omitted from this statement as the divisions and departments will absorb the June overhead expenses in their July accounts. All of the above figures were absorbed in fiscal year 1910 accounts.

In each division and department these general expenses are prorated to the different construction subaccounts in proportion to the benefits received. Items for "freight transportation" and "compensation to injured employees" enter into the cost of the work as direct "division costs."

Included in the foregoing expenditures from canal appropriations are certain expenditures which have not yet been charged to any particular item of construction work or to any department or division. These "general items," as they are called, to June 30, 1910, amounted to $80,885,694.93, principally for the following:

General items.

Payment to the New Panama Canal Company	$40,000,000
Payment to the Republic of Panama	10,000,000
Construction and repair of buildings	9,773,000
Relocation of Panama Railroad	5,153,000
Loans to Panama Railroad Company	3,347,000
Construction of Zone water works, sewers, and roads	4,881,000
Construction of water works, sewers, and pavements, Panama and Colon.	2,538,000
Steamers and other plant in Panama Railroad service	3,108,000

The cost-keeping methods of the commission consist of:

1. Monthly compilations of cost data made in the chief engineer's office, which are worked up as a permanent record of the work accomplished and are used to indicate generally the efficiency with which the various portions of the work are being carried forward.

2. Division cost records kept in the various division offices consisting of both monthly records in detail and also of daily performance and unit cost sheets, in order to give the division engineers daily information on unit costs and keep them in close touch with the work in their respective divisions.

The monthly cost reports forwarded to the chief engineer's office in connection with the cost keeping include the following forms:

No. 132–C. E.—Monthly statement of total expenditures by account numbers. (Size, 17 by 11 inches.)

No. 220–C. E.—Monthly statement of operations, miscellaneous plants. (Size, 8 by 13 inches.)

No. 221–C. E.—Monthly manufacturing account statement covering work done on manufacturing orders. (Size, 17 by 18 inches.)

No. 222–C. E.—Statement of construction and repair work authorized, performed, and in progress. (Size, 17 by 18 inches.)

No. 223–C. E.—Report of foundry operations. (Size, 8 by 16 inches.)

No. 261–C. E.—Report of expenditures for construction work. (Size, 17 by 14 inches.)

No. 263–C. E.—Expenditures for plant and equipment. (Size, 17 by 14 inches.)

The headings of these forms, or the forms themselves, are as follows:

[Form 132-2 C. E.]

ISTHMIAN CANAL COMMISSION.

Correct:

....

ABSTRACT OF EXPENDITURES.

..............................*for the month of*........191.... Title............

(Department or division.)

Account No.	Detail.	Total.	Labor.	Material (including plant and subsistence stores).	From other divisions.			Miscellaneous claims.	Arbitraries.	General administrative expenses.	General expenses.		
					Labor.	Material.	Service.						
1	2	3	4	5	6	7	8	9	10	11	12	13	14
......	....	......	......	....	......	......	......	......	......	......	......	......	......
......	....	......	......	....	......	......	......	......	......	......	......	......	......
......	....	......	......	....	......	......	......	......	......	......	......	......	......

[Form C. E., 220.]

ISTHMIAN CANAL COMMISSION,

DEPARTMENT OF CONSTRUCTION AND ENGINEERING.

.... department or division.

Monthly statement of operations, miscellaneous plants.

For report of operations of rock crushers, sand plants, concrete-block plants, truck gardens, electric light and power plants, air compressors, and field repair shops (such as Cocoli, Cucaracha, Cunette, and Gatun shops), also Lirio planing mill and the printing plant.

Operations of...........................month of....................19........

Balance from last report................. ....

Expenses during month:

Labor and supervision............... ....

Material......................... ....

Transportation...................... ....

Other expenses..................... ....

Total expenses during month...................... ....

Total debits...................................... ....

Credits:

Output (taken up in material account) ....

....

....

....

....

Balance to next account........................ ....

Remarks:

(Signed) ....

Head of department or division.

[Form C. E. 221.]

ISTHMIAN CANAL COMMISSION,

DEPARTMENT OF CONSTRUCTION AND ENGINEERING,

.....................division. ....shop.

Monthly manufacturing account statement covering work done on manufacturing orders during the month of .... 19.....

Manufacturing order No. (Form 159-C. E.)	Shop order No.	Description of work.	For division or department.	Per cent status.	Charges current month.			Total charges to date.	Estimated cost.	Bill or invoice number.
					Labor.	Material.	Total.			

[Form C. E. 222.]

ISTHMIAN CANAL COMMISSION,

DEPARTMENT OF CONSTRUCTION AND ENGINEERING.

........................division.........................

Monthly work report for the chairman and chief engineer.—Statement of construction and repair work authorized, performed, and in progress for month of .... 19.....

[Totals of the following reports to be carried on this report: C. E. 220, Operation miscellaneous plants; C. E. 221, Manufacturing account statement; C. E. 223, Foundry operations; as well as shop superintendence, repairs and renewals of shop machinery and tools, and shop expenses.]

Shop order or authority.	Description of work.	For division or department.	Per cent complete.	Charges current month.				Total charges to date.	Estimated cost.	Remarks.
				Labor.	Material.	Other expenses.	Total.			

[C. E. 223.]

Report of Iron Foundry Operations,

.....................shops,

For the month of.....................191..

Material.	Weight.	Cost.	Amount.	Cost per ton.	Total.
Pattern material					
Coke					
Coal					
Charcoal pig iron					
Pig No. 1					
Pig No. 2					
Pig No. 3					
Pig No. 4					
Iron scrap					
Steel scrap					
Proportion material expense for running shops.					
Total raw material expense					

Supplies.	Amount.	Cost per ton.	Total.
New tools			
Repairs, tools and machinery			
Flour, facing			
Nails, sand, etc			
Total expense supplies			

Labor.	Amount.	Cost per ton.	Total.
Proportion labor expense for running shops			
Core room			
Molding			
Cleaning castings			
Cupola			
Patternmaking			
Repairs, tools and machinery			
Cleaning foundry			
Miscellaneous labor			
Total labor			
Add 5 per cent for supervisiou			
Total labor expense			
Total expense—material, supplies, and labor			

SUMMARY.

Total charcoal pig iron		Total gray iron castings	
Total pig No. 1		Total steel castings	
Total pig No. 2		Total output	
Total pig No. 3		Total returned gates	
Total pig No. 4		Total loss in melting	
Total iron scrap			
Total steel scrap			
Total returns			
Total weight		Total weight	
Total expense		Total weight good castings	

Average cost per pound	
Average cost per pound labor	
Average cost per pound material	

REMARKS.

......pounds iron castings made at a total cost of $......, or......per pound.
......pounds steel castings made at a total cost of $......, or......per pound.
Labor expense is...... per cent of total cost of operation.
Material expense is......per cent of total cost of operation.
......castings made, average weight of each......pounds.
......patterns made, average cost of each $.......
Loss in melting is......per cent of total output.
Return is......per cent of total output.

[Form 261-C. E.]

ISTHMIAN CANAL COMMISSION,

............DIVISION.

Construction expenditures for the month of...................., 191...

Account.		Unit.	Current month.					Unit cost.	Fiscal year to date.					Unit cost.
No.	Title.		Work done, quantity.	Labor.	Material.	Charges from other divisions.	Total.		Work done, quantity.	Labor.	Material.	Charges from other divisions.	Total.	

[Form 263-C. E.]

ISTHMIAN CANAL COMMISSION,

............DIVISION.

Plant and equipment expenditures for the month of...................., 191...

Items.	Labor.	Material.	Charges from other divisions.	Total.	Total cost to date.	Completed cost.	Estimated cost.	Remarks.

Since July 1, 1909, all expenditures for plant, including all charges under that head accruing to that date, have been distributed to the different construction accounts in proportion to the benefits received by each. The plant arbitrary for each kind of work was established by dividing the total estimated expenditures by the total estimated quantity of work, and each month's costs include an allowance for plant cost, obtained from the quantity of work performed multiplied by the plant arbitrary. Upon the completion of the work all plant costs will have been absorbed by the work. The plant arbitraries are to be revised at intervals not greater than one year, so as to make the distribution of plant costs in the monthly cost statements as uniform as practicable.

The construction divisions fill out and forward to the chief engineer's office by the 20th of each month the above-mentioned forms,

covering the cost of work during the preceding month, except Form No. 132, which is received from all departments and divisions not later than the 25th of the month following the one it covers and which contains the statement of total expenditures classified by accounts. From this data the detailed monthly cost sheets are compiled in the chief engineer's office for the different classes of work.

Construction work costs include "division cost" plus "general expenses." "Division cost" is made up of all labor and material costs directly applied to the work plus plant arbitrary. "General expenses" include the expenses of the chief engineer's office, of the quartermaster's and subsistence departments, of the examiner of accounts' office, and disbursing office, expenses in the United States, and miscellaneous.

For the different classes of work costs are compiled under the following headings:

- Atlantic division:
  - Dry excavation, prism.
  - Dredging excavation, prism.
  - Gatun Dam—
    - Dredging excavation.
    - Dry filling.
    - Hydraulic filling.
    - Paving dam.
  - Gatun spillway—
    - Dry excavation.
    - Preparing foundations.
    - Masonry.
    - Ironwork.
    - Back filling.
  - Gatun locks—
    - Dry excavation.
    - Dredging excavation.
    - Preparing foundations.
    - Masonry.
    - Ironwork.
    - Back filling.
  - Construction Gatun-Mindi levee.
  - Colon breakwater.
  - Stone production.
  - Sand production.
  - Operation, power houses.
- Central division:
  - Dry excavation—
    - Prism.
    - By contract.
  - Dredging excavation, prism.
  - Clearing canal line.
- Pacific division:
  - Dry excavation, prism.
  - Dredging excavation, prism.
  - Pedro Miguel Dam—
    - Dry excavation.
    - Dry filling.
    - Concrete in dam.
  - Pedro Miguel locks—
    - Dry excavation.
    - Preparing foundations.
    - Masonry.
    - Ironwork.
    - Back filling.
  - Miraflores locks—
    - Dry excavation.
    - Dredging excavation.
    - Preparing foundations.
    - Masonry.
    - Ironwork.
    - Back filling.
  - Miraflores Dam—
    - Dry excavation.
    - Concrete in dam.
    - Dry filling.
    - Hydraulic fill.
  - Stone production.
  - Sand production.
  - Operation, power houses.

Additional detalis are supplied as the condition of the work warrants or new units of construction are started.

During the year the average cost of dry excavation in the central division and of wet excavation in the Atlantic and Pacific divisions has been as follows:

Division and item of work.	Work.	Plant.	General expenses.	Total.
Central division (dry excavation)	$0.5399	$0.1300	$0.0646	$0.7345
Atlantic division (wet excavation)	.1752	.0608	.0265	.2625
Pacific division (wet excavation)	.1491	.0916	.0228	.2635

The average cost of concrete laid in the Atlantic and Pacific divisions during the year was as follows:

Division.	Work.	Plant.	General expenses.	Total.
Atlantic division	$6.8674	$0.6046	$0.4088	[a] $7.8808
Pacific division	5.6480	.4539	.5215	6.6234

[a] Includes cost of concrete in spillway, Gatun.

The work is being carried on within the estimate of December, 1908. Every effort is being made to reduce the unit costs still further.

Each construction division has its own cost-keeping forms, by which the costs can be analyzed in as great detail as desired. The unit costs are compiled from day to day so that the progress of the work can be closely followed.

During the year Mr. A. B. Nichols has remained office engineer in charge of the drafting room, drawings, and old French records in the chief engineer's office.

Mr. W. O. Johnson was appointed inspector of shops on May 1, 1910. Upon his resignation, Maj. T. C. Dickson, U. S. Army, was appointed inspector of shops, effective June 27, 1910.

Mr. James G. Craig was appointed senior traveling engineer on July 16, 1909, and Mr. A. G. Stone junior traveling engineer on August 6, 1909.

Mr. Ad. Faure was appointed chief accountant in charge of cost keeping in the chief engineer's office on February 1, 1910.

All officers and employees have performed their work in an efficient manner during the year.

Very respectfully,

H. H. Rousseau,
Civil Engineer, U. S. Navy, Member Isthmian Canal Commission, Assistant to the Chief Engineer.

Col. Geo. W. Goethals, *Corps of Engineers, U. S. Army, Chairman and Chief Engineer, Isthmian Canal Commission, Culebra, Canal Zone.*

APPENDIX H.

REPORT OF AD. FAURE, COST-KEEPING ACCOUNTANT IN OFFICE OF CHAIRMAN AND CHIEF ENGINEER.

ISTHMIAN CANAL COMMISSION,
OFFICE OF CHAIRMAN AND CHIEF ENGINEER,
Culebra, Canal Zone, September 1, 1910.

SIR: I have the honor to submit the following report of the work of this office for the fiscal year 1910. Its duties consist in supervising and verifying the statements of costs furnished by the division engineers, preparing statistical reports, and attending to such other accounting work as may be assigned by the chief engineer.

The cost reports furnished prior to January 1, 1910, carried but little detail, except for excavation work, and were not available until five or six weeks after the close of the month, nor did they contain any charge for plant and equipment, which expenditures were carried in the accounts in total only. A study was made of the methods in vogue in the divisions with a view of standardizing the work and producing results at an earlier date.

Effective July 1, 1909, the cost of machinery and equipment, and its installation, was distributed to the various construction divisions, so as to locate these expenditures to the various units of construction.

Large sums had been expended in developing quarries and sand pits for production of material for concrete for the locks and in installing the necessary machinery. When concreting was begun it became apparent that some method must be devised by which these expenditures would be absorbed in the cost of the product so that the amount expended for preliminary work, machinery, and installation would be taken up in the cost of the masonry. Plants for handling the material and for mixing and handling the concrete had been erected and their cost must likewise be absorbed in masonry costs.

A cost-keeping system was adopted, effective January 1, 1910, which provides a uniform classification in the various construction divisions, so that the same items of expense enter into the cost of each division for work of a like character. A system of arbitraries was adopted with a view of absorbing into the construction cost all expenditures for plant and equipment, based on the estimated cost and the estimated amount of work to be accomplished. This method contemplates the absorption of the total expenditures for plant, and does not take into consideration any salvage which may be realized after the completion of the work. These arbitraries will be revised semi-annually.

In order to state the accounts uniformly, the plant arbitraries were applied to all construction work prior to January 1, 1910. On June

30, 1910, there remained in the plant accounts $11,917,069.98, to be absorbed into the work after that date, and there had been absorbed $13,782,382.83.

The system provides complete control over expenditures for labor, material, and services. The costs for labor are prepared from daily reports of foremen in charge of the gangs and are balanced against the monthly pay rolls; the costs for material, from the orders drawn on the storehouses and are balanced against the chief quartermaster's reports of the value of material issued.

By frequent visits to the division offices and to the work in progress, this office keeps in touch with conditions and the reports are analyzed with a view of ascertaining the correctness of the classification.

Sand, stone, and cement for concrete are priced at the cost of delivery at the warehouses or storage piles. In the case of stone and sand, prices are based on the monthly output and the expenditures in connection therewith, and the price at which this material is charged into the work is the average resulting from the cost of the quantity left in storage at the close of the preceding month and the cost of production during the month.

As the new classification of costs is more detailed than that which had been previously used, it was found impracticable to reclassify the expenditures in detail prior to January 1, 1910.

The total unit costs for the various parts of the work for the first and the second six months of this fiscal year, the total for the fiscal year and for the period from the inception of the work to June 30, 1910, are shown in the tables under Exhibit A. Detailed costs for the last six months of the fiscal year of such items as can be expressed in units are shown in tables under Exhibit B. There are also included therein tables showing the detailed costs of sand and stone produced by the Atlantic and Pacific divisions.

Very respectfully,

AD. FAURE,
Cost-keeping Accountant.

Col. GEO. W. GOETHALS, Corps of Engineers, U. S. Army,
Chairman and Chief Engineer,
Isthmian Canal Commission, Culebra, Canal Zone.

INDEX TO EXHIBITS ACCOMPANYING REPORT OF AD. FAURE, COST-KEEPING ACCOUNTANT IN OFFICE OF CHAIRMAN AND CHIEF ENGINEER.

EXHIBIT A.—*Statements of construction costs from May 4, 1904, to June 30, 1910.*

EXHIBIT B.—*Detailed construction costs per cubic yard, January to June, 1910, inclusive.*

EXHIBIT A.

TABLE 1.—*Statement of construction expenditures to June 30, 1910.*

ATLANTIC DIVISION.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
Dry excavation—Prism:	*Cubic yards.*						
July 1 to Dec. 31, 1909	324,716	$199,126.80	$0.6132	$24,546.65	$0.0756	$223,673.45	$0.6888
Jan. 1 to June 30, 1910	....	2,789.56	....	438.90	....	3,228.46	....
Fiscal year 1910	324,716	201,916.36	.6218	24,985.55	.0770	226,901.91	.6988
May 4, 1904, to June 30, 1909	1,152,105	673,330.97	.5844	102,017.26	.0886	775,348.23	.6730
Total to June 30,1910	1,476,821	875,247.33	.5927	127,002.81	.0860	1,002,250.14	.6787
Plant: Amount to be absorbed after June 30, 1910	....	....	....	....	....	50,614.80	....
Total	....	....	....	....	....	1,052,864.94	....
Dredging excavation—Prism:							
July 1 to Dec. 31, 1909	2,443,659	542,718.97	.2221	47,184.11	.0193	589,903.08	.2414
Jan. 1 to June 30, 1910	2,512,001	626,948.63	.2496	84,186.06	.0335	711,134.69	.2831
Fiscal year 1910	4,955,660	1,169,667.60	.2360	131,370.17	.0265	1,301,037.77	.2625
May 4, 1904, to June 30, 1909	13,188,123	2,654,951.70	.2013	273,425.93	.0207	2,928,377.63	.2220
Total to June 30,1910	18,143,783	3,824,619.30	.2108	404,796.10	.0223	4,229,415.40	.2331
Plant: Amount to be absorbed after June 30, 1910	....	....	....	....	....	896,389.81	....
Total	....	....	....	....	....	5,125,805.21	....
GATUN SPILLWAY.							
Dry excavation:							
July 1 to Dec. 31,1909	42,717	46,279.30	1.0834	7,502.59	.1756	53,781.89	1.2590
Jan. 1 to June 30, 1910	79,770	71,666.17	.8984	7,957.72	.0998	79,623.89	.9982
Fiscal year 1910	122,487	117,945.47	.9629	15,460.31	.1262	133,405.78	1.0891
May 4,1904, to June 30, 1909	1,296,332	778,514.20	.6006	127,355.38	.0982	905,869.58	.6988
Total to June 30,1910	1,418,819	896,459.67	.6318	142,815.69	.1007	1,039,275.36	.7325
Preparing foundations:							
Jan. 1 to June 30, 1910	4,723	18,632.78	3.9451	2,732.07	.5785	21,364.85	4.5236
Total to June 30,1910	4,723	18,632.78	3.9451	2,732.07	.5785	21,364.85	4.5236
Masonry:							
July 1 to Dec. 31, 1909	20,547	199,415.64	9.7053	14,059.76	.6843	213,475.40	10.3896
Jan. 1 to June 30, 1910	33,085	261,922.63	7.9167	13,320.38	.4026	275,243.01	8.3193
Fiscal year 1910	53,632	461,338.27	8.6019	27,380.14	.5105	488,718.41	9.1124
May 4, 1904, to June 30, 1909	30,464	223,203.73	7.3268	20,565.26	.6751	243,768.99	8.0019
Total to June 30,1910	84,096	684,542.00	8.1400	47,945.40	.5701	732,487.40	8.7101
Ironwork:							
Jan. 1 to June 30, 1910	....	346.26	....	41.60	....	387.86	....
Total to June 30,1910	....	346.26	....	41.60	....	387.86	....
Back filling:							
Jan. 1 to June 30, 1910	1,781	1,005.69	.5647	93.55	.0525	1,099.24	.6172
Total to June 30,1910	1,781	1,005.69	.5647	93.55	.0525	1,099.24	.6172
Total Gatun spillway	....	....	....	....	....	1,794,614.71	....

TABLE 1.—*Statement of construction expenditures to June 30, 1910*—Continued.

ATLANTIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
GATUN DAM.							
Dredging excavation:							
May 4, 1904, to June 30, 1909	*Cubic yards.* 38,425	$18,322.71	$0.4769	$1,718.48	$0.0447	$20,041.19	$0.5216
Total to June 30,1910	38,425	18,322.71	.4769	1,718.48	.0447	20,041.19	.5216
Dry filling:							
July 1 to Dec. 31, 1909	996,796	318,456.97	.3195	43,464.43	.0436	361,921.40	.3631
Jan. 1 to June 30, 1910	1,558,401	439,371.18	.2819	43,613.81	.0280	482,984.99	.3099
Fiscal year 1910	2,555,197	757,828.15	.2966	87,078.24	.0340	844,906.39	.3306
May 4, 1904, to June 30, 1909	2,244,622	927,319.57	.4131	181,339.46	.0808	1,108,659.03	.4939
Total to June 30,1910	4,799,819	1,685,147.72	.3511	268,417.70	.0559	1,953,565.42	.4070
Hydraulic filling:							
July 1 to Dec. 31, 1909	1,376,430	280,093.05	.2035	21,732.21	.0158	301,825.26	.2193
Jan. 1 to June 30, 1910	1,556,745	506,548.91	.3254	38,178.36	.0245	544,727.27	.3499
Fiscal year 1910	2,933,175	786,641.96	.2682	59,910.57	.0204	846,552.53	.2886
May 4, 1904, to June 30, 1909	720,047	162,553.19	.2156	34,540.85	.0581	197,094.04	.2737
Total to June 30,1910	3,653,222	949,195.15	.2598	94,451.42	.0259	1,043,646.57	.2857
Paving:							
Jan. 1 to June 30, 1910	22,037	6,372.92	.2892	415.58	.0189	6,788.50	.3081
Total to June 30,1910	22,037	6,372.92	.2892	415.58	.0189	6,788.50	.3081
Total Gatun dam	....	....	....	....	....	3,024,041.68	....
Total Gatun dam and spillway	....	....	....	....	....	4,818,656.39	....
Plant:							
Amount to be absorbed after June 30, 1910	....	....	....	....	....	242,006.75	....
Total	....	....	....	....	....	5,060,663.14	....
GATUN LOCKS.							
Dry excavation:							
July 1 to Dec. 31, 1909	302,593	325,248.51	1.0749	36,487.68	.1206	361,736.19	1.1955
Jan. 1 to June 30, 1910	536,709	362,353.89	.6751	37,503.79	.0699	399,857.68	.7450
Fiscal year 1910	839,302	687,602.40	.8193	73,991.47	.0881	761,593.87	.9074
May 4, 1904, to June 30, 1909	3,240,218	1,729,279.35	.5337	217,726.78	.0672	1,947,006.13	.6009
Total to June 30, 1910	4,079,520	2,416,881.75	.5924	291,718.25	.0715	2,708,600.00	.6639
Dredging excavation:							
May 4, 1904, to June 30, 1909	488,533	79,978.65	.1637	9,427.51	.0193	89,406.16	.1830
Total to June 30, 1910	488,533	79,978.65	.1637	9,427.51	.0193	89,406.16	.1830
Preparing foundations:							
Excavation—							
Jan. 1 to June 30, 1910	33,843	85,109.77	2.5148	13,392.73	.3957	98,502.50	2.9105
Total to June 30, 1910	33,843	85,109.77	2.5148	13,392.73	.3957	98,502.50	2.9105
Filling—							
Jan. 1 to June 30, 1910	17,883	10,607.43	.5932	....	....	10,607.43	.5932
Total to June 30, 1910	17,883	10,607.43	.5932	....	....	10,607.43	.5932

TABLE 1.—*Statement of construction expenditures to June 30, 1910*—Continued.

ATLANTIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
GATUN LOCKS—cont'd.							
Masonry:	*Cubic yards.*						
July 1 to Dec. 31, 1909	116,072	$926,570.83	$7.9827	$64,471.85	$0.5555	$991,042.68	$8.5382
Jan. 1 to June 30, 1910	397,731	2,852,592.98	7.1722	140,125.10	.3523	2,992,718.08	7.5245
Fiscal year 1910	513,803	3,779,163.81	7.3553	204,596.95	.3982	3,983,760.76	7.7535
May 4, 1904, to June 30, 1909		15,093.59		2,054.67		17,148.26	
Total to June 30, 1910	513,803	3,794,257.40	7.3846	206,651.62	.4022	4,000,909.02	7.7868
Iron work:							
July 1 to Dec. 31, 1909		69,659.09		4,249.36		73,908.45	
Jan. 1 to June 30, 1910		156,895.28		21,862.95		178,758.23	
Fiscal year 1910		226,554.37		26,112.31		252,666.68	
Total to June 30, 1910		226,554.37		26,112.31		252,666.68	
Backfilling:							
July 1 to Dec. 31, 1909	807	321.78	.3987			321.78	.3987
Jan. 1 to June 30, 1910	3,383	4,489.74	1.3271	388.29	.1148	4,878.03	1.4419
Fiscal year 1910	4,190	4,811.52	1.1483	388.29	.0927	5,199.81	1.2410
Total to June 30, 1910	4,190	4,811.52	1.1483	388.29	.0927	5,199.81	1.2410
Total Gatun locks						7,165,891.60	
Plant:							
Amount to be absorbed after June 30, 1910						1,201,641.33	
Total						8,367,532.93	
GATUN-MINDI LEVEE.							
Jan. 1 to June 30, 1910	126,002	51,789.04	.4110	6,125.69	.0486	57,914.73	.4596
Total to June 30, 1910	126,002	51,789.04	.4110	6,125.69	.0486	57,914.73	.4596
COLON BREAKWATER.							
July 1 to Dec. 31, 1909		7,414.91				7,414.91	
Jan. 1 to June 30, 1910		36,358.40		4,910.83		41,269.23	
Fiscal year 1910		43,773.31		4,910.83		48,684.14	
May 4, 1904, to June 30, 1909		7,436.72				7,436.72	
Total to June 30, 1910		51,210.03		4,910.83		56,120.86	
Plant:							
Amount to be absorbed after June 30, 1910						449,179.71	
Total						505,300.57	
Manufacturing plants:							
Amounts to be absorbed in cost of products after June 30, 1910:							
Electric power plant						194,462.88	
Porto Bello quarry						818,305.55	
Nombre de Dios sand plant						326,420.52	
Sea transportation plant						1,165,885.34	
Total						2,505,074.29	
Total Atlantic division						22,675,155.81	

TABLE 2.—*Statement of construction expenditures to June 30, 1910.*

CENTRAL DIVISION.

	Quantity.	Total division expenses including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
Dry excavation—Prism:	*Cubic yards.*						
July 1 to Dec. 31, 1909.	8,257,221	$5,842,726.66	$0.7076	$711,755.95	$0.0862	$6,554,482.61	$0.7938
Jan. 1 to June 30, 1910..	9,574,956	6,102,535.27	.6373	441,054.63	.0461	6,543,589.90	.6834
Fiscal year 1910.....	17,832,177	11,945,261.93	.6699	1,152,810.58	.0646	13,098,072.51	.7345
May 4, 1904, to June 30, 1909..............	40,983,366	37,540,874.34	.9160	4,615,073.19	.1126	42,155,947.53	1.0286
Total to June 30, 1910	58,815,543	49,486,136.27	.8414	5,767,883.77	.0980	55,254,020.04	.9394
Clearing canal line:							
Jan. 1 to June 30, 1910..	[b] 2,098	....	....	....	....	134,857.24	64.2789
Total to June 30, 1910	[b] 2,098	....	....	....	....	134,857.24	64.2789
Dredging excavation: [a]							
May 4, 1904, to June 30, 1909..............	....	8,067.72	....	1,730.68	....	9,798.40	....
Total to June 30, 1910	....	8,067.72	....	1,730.68	....	9,798.40	....
Plant:							
Amount to be absorbed after June 30, 1910...............	....	....	....	....	....	2,841,572.46	....
Total central division.............	....	....	....	....	....	58,240,248.14	....

[a] Surveys only. [b] Acres.

TABLE 3.—*Statement of construction expenditures to June 30, 1910.*

PACIFIC DIVISION.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
Dry excavation—Prism:	*Cubic yards.*						
July 1 to Dec. 31, 1909.	....					....	....
Jan. 1 to June 30, 1910.	99,703	$63,266.48	$0.6345	$6,622.63	$0.0664	$69,889.11	$0.7009
Fiscal year 1910.....	99,703	63,266.48	.6345	6,622.63	.0664	69,889.11	.7009
May 4, 1904, to June 30, 1909...........	139,470	119,747.16	.8586	21,514.28	.1542	141,261.44	1.0128
Total to June 30, 1910..............	239,173	183,013.64	.7652	28,136.91	.1176	211,150.55	.8828
Plant:							
Amount to be absorbed after June 30, 1910..........	....	....	....	....	....	279,108.22	....
Total..............	....	....	....	....	....	490,258.77	....
Dredging excavation—Prism:							
July 1 to Dec. 31, 1909.	4,095,591	841,920.03	.2055	88,387.28	.0216	930,307.31	.2271
Jan. 1 to June 30, 1910.	2,761,632	808,974.35	.2929	67,704.81	.0245	876,679.16	.3174
Fiscal year 1910.....	6,857,223	1,650,894.38	.2408	156,092.09	.0227	1,806,986.47	.2635
May 4, 1904, to June 30, 1909...........	16,180,107	3,427,748.61	.2118	277,360.96	.0172	3,705,109.57	.2290
Total to June 30, 1910..............	23,037,330	5,078,642.99	.2205	433,453.05	.0188	5,512,096.04	.2393

TABLE 3.—*Statement of construction expenditures to June 30, 1910*—Continued.

PACIFIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
Plant:							
Amount to be absorbed after June 30, 1910	*Cubic yards.*					$695,885.31	
Total						6,207,981.35	
PEDRO MIGUEL DAM.							
Dry excavation:							
Jan. 1 to June 30, 1909		$925.47				925.47	
Total to June 30, 1910		925.47				925.47	
Dry filling:							
July 1 to Dec. 31, 1909	3,105	1,963.61	$0.6324	$199.62	$0.0643	$2,163.23	$0.6967
Jan. 1 to June 30, 1910	90,686	34,242.02	.3776	3,692.69	.0407	37.934.71	.4183
Fiscal year 1910	93,791	36,205.63	.3860	3,892.31	.0415	40,097.94	.4275
May 4, 1904, to June 30, 1909	167,061	76,517.58	.4580	9,985.14	.0598	86,502.72	.5178
Total to June 30, 1910	260,852	112,723.21	.4321	13,877.45	.0532	126,600.66	.4853
Total Pedro Miguel dam						127,526.13	
PEDRO MIGUEL LOCKS.							
Dry excavation:							
July 1 to Dec. 31, 1909	271,904	318,312.90	1.1707	44,213.16	.1626	362,526.06	1.3333
Jan. 1 to June 30, 1910	26,596	36,211.91	1.3615	4,308.71	.1620	40,520.62	1.5235
Fiscal year 1910	298,500	354,524.81	1.1876	48,521.87	.1626	403,046.68	1.3502
May 4, 1904, to June 30, 1909	720,157	508,834.12	.7066	76,019.61	.1055	584,853.73	.8121
Total to June 30, 1910	1,018,657	863,358.93	.8475	124,541.48	.1223	987,900.41	.9698
Preparing foundations:							
Jan. 1 to June 30, 1910	44,948	126,722.55	2.8193	14,916.60	.3319	141,639.15	3.1512
Total to June 30, 1910	44,948	126,722.55	2.8193	14,916.60	.3319	141,639.15	3.1521
Masonry:							
July 1 to Dec. 31, 1909	33,856	222,718.85	6.5784	35,515.30	1.0490	258,234.15	7.6274
Jan. 1 to June 30, 1910	133,013	793,388.57	5.9647	51,189.68	.3849	844,578.25	6.3496
Fiscal year 1910	166,869	1,016,107.42	6.0892	86,704.98	.5196	1,102,812.40	6.6088
Total to June 30, 1910	166,869	1,016,107.42	6.0892	86,704.98	.5196	1,102,812.40	6.6088
Iron work:							
July 1 to Dec. 31, 1909		45,261.74				45,261.74	
Jan. 1 to June 30, 1910		98,229.77		3,834.93		102,064.70	
Fiscal year 1910		143,491.51		3,834.93		147,326.44	
May 4, 1904, to June 30, 1909		108,843.27		8,190.96		117,034.23	
Total to June 30, 1910		252,334.78		12,025.89		264,360.67	

TABLE 3.—*Statement of construction expenditures to June 30, 1910*—Continued.

PACIFIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
PEDRO MIGUEL LOCKS—con.							
Back filling:	Cubic yards.						
Jan. 1 to June 30, 1910.	9,616	$2,737.77	$0.2847	$278.81	$0.0290	$3,016.58	$0.3137
Total to June 30, 1910	9,616	2,737.77	.2847	278.81	.0290	3,016.58	.3137
Total Pedro Miguel locks						2,499,729.21	
Total Pedro Miguel locks and dam						2,627,255.34	
Plant:							
Amount to be absorbed after June 30, 1910						619,233.40	
Total						3,246,488.74	
MIRAFLORES DAM AND SPILLWAY.							
Dry filling:							
July 1 to Dec. 31, 1909.	108,673	91,632.79	.8432	11,196.31	.1030	102,829.10	.9462
Jan. 1 to June 30, 1910.	48,810	15,053.25	.3084	1,632.27	.0334	16,685.52	.3418
Fiscal year 1910	157,483	106,686.04	.6774	12,828.58	.0815	119,514.62	.7589
May 4, 1904, to June 30, 1909	363,418	172,058.40	.4694	22,311.58	.0654	194,369.98	.5348
Total to June 30, 1910	520,901	278,744.44	.5351	35,140.16	.0675	313,884.60	.6026
Hydraulic filling:							
Jan. 1 to June 30, 1910.		3,665.16		412.70		4,077.86	
Total to June 30, 1910		3,665.16		412.70		4,077.86	
Masonry—Core wall:							
Jan. 1 to June 30, 1910.		388.59		40.92		429.51	
Total to June 30, 1910		388.59		40.92		429.51	
Dry excavation:							
Jan. 1 to June 30, 1910.	550	299.74	.5450	9.68	.0176	309.42	.5626
Fiscal year 1910	550	299.74	.5450	9.68	.0176	309.42	.5626
May 4, 1904, to June 30, 1909	13,986	19,681.84	1.4073			19,681.84	1.4073
Total to June 30, 1910	14,530	19,981.58	1.3746	9.68	.0007	19,991.26	1.3753
Total						338,383.23	
MIRAFLORES LOCKS.							
Dry excavation:							
Diversion—							
Jan. 1 to June 30, 1910	5,885	2,028.98	.3448			2,028.98	.3448
Total to June 30, 1910	5,885	2,028.98	.3448			2,028.98	.3448
In locks—							
July 1 to Dec. 31, 1909	180,909	236,887.82	1.3094	35,576.72	.1967	272,464.54	1.5061
Jan. 1 to June 30, 1910	48,884	66,938.06	1.3693	7,348.85	.1503	74,286.91	1.5196
Fiscal year 1910.	229,793	303,825.88	1.3222	42,925.57	.1868	346,751.45	1.5090
May 4, 1904, to June 30, 1909	1,120,342	910,973.87	.8131	164,599.98	.1469	1,075,573.85	.9600
Total to June 30, 1910	1,350,135	1,214,799.75	.8998	207,525.55	.1537	1,422,325.30	1.0535

TABLE 3.—*Statement of construction expenditures to June 30, 1910*—Continued.

PACIFIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
MIRAFLORES LOCKS—con.							
Dredging excavation:	*Cubic yards.*						
July 1 to Dec. 31, 1909	141,759	$57,985.09	$0.4090	$5,231.78	$0.0369	$63,216.87	$0.4459
Jan. 1 to June 30, 1910	....	13,799.16	....	1,367.37	....	15,166.53	....
Fiscal year 1910	141,759	71,784.25	.5063	6,599.15	.0466	78,383.40	.5529
May 4, 1904, to June 30, 1909	167,888	57,408.31	.3418	6,587.95	.0393	63,996.26	.3811
Total to June 30, 1910	309,647	129,192.56	.4172	13,187.10	.0426	142,379.66	.4598
Preparing foundations:							
Jan. 1 to June 30, 1910	64,036	124,669.74	1.9469	15,952.08	.2491	140,621.82	2.1960
Total to June 30, 1910	64,036	124,669.74	1.9469	15,952.08	.2491	140,621.82	2.1960
Masonry:							
Jan. 1 to June 30, 1910	1,630	12,050.56	7.3929	1,173.62	.7200	13,224.18	8.1129
Total to June 30, 1910	1,630	12,050.56	7.3929	1,173.62	.7200	13,224.18	8.1129
Ironwork:							
Jan. 1 to June 30, 1910	....	92,950.46	....	2,490.41	....	95,440.87	....
Total to June 30, 1910	....	92,950.46	....	2,490.41	....	95,440.87	....
Back filling:							
July 1 to Dec. 31, 1909	54,779	33,156.14	.6053	4,946.99	.0903	38,103.13	.6956
Jan. 1 to June 30, 1910	66,301	19,014.18	.2868	1,794.19	.0271	20,808.37	.3139
Fiscal year 1910	121,080	52,170.32	.4309	6,741.18	.0557	58,911.50	.4866
May 4, 1904, to June 30, 1909	409,211	36,801.83	.0899	6,246.87	.0153	43,048.70	.1052
Total to June 30, 1910	530,291	88,972.15	.1678	12,988.05	.0245	101,960.20	.1923
Total	....	....	....	....	....	1,917,981.01	....
Total Miraflores locks and dams	....	....	....	....	....	2,256,364.24	....
LA BOCA LOCKS AND DAMS.							
(Subsequently abandoned owing to change of plans.)							
Dry excavation:							
May 4, 1904, to June 30, 1909	78,233	131,254.40	1.6777	27,088.89	.3463	158,343.29	2.0240
Total to June 30, 1910	78,233	131,254.40	1.6777	27,088.89	.3463	158,343.29	2.0240
Construction:							
Dam—							
May 4, 1904, to June 30, 1909	....	288,601.56	....	26,748.51	....	315,350.07	....
Total to June 30, 1910	....	288,601.56	....	26,748.51	....	315,350.07	....
Locks—							
May 4, 1904, to June 30, 1909	....	145,828.37	....	13,478.03	....	159,306.40	....
Total to June 30, 1910	....	145,828.37	....	13,478.03	....	159,306.40	....
Total	....	....	....	....	....	632,999.76	....
Total lower locks, Pacific entrance	....	....	....	....	....	2,889,364.00	....

TABLE 3.—*Statement of construction expenditures to June 30, 1910*—Continued.

PACIFIC DIVISION—Continued.

	Quantity.	Total division expenses, including arbitraries.		Administrative and general expenses.		Total cost.	
		Amount.	Unit cost.	Amount.	Unit cost.	Amount.	Unit cost.
LA BOCA LOCKS AND DAMS—continued.							
Plant:							
Amount to be absorbed after June 30, 1910	*Cubic yards.*					$686,071.65	
Total						3,575,435.65	
NAOS ISLAND BREAKWATER.							
(Constructed by central division. Charges represent cost of trestling only, as that is considered the extra cost due to disposing of spoils at this point.)							
July 1 to Dec. 31, 1909		$33,856.92				33,856.92	
Jan. 1 to June 30, 1910		2,990.81		$20.03		3,010.84	
Fiscal year 1910		36,847.73		20.03		36,867.76	
Total to June 30, 1910		36,847.73		20.03		36,867.76	
Manufacturing plants:							
Amounts to be absorbed in cost of products after June 30, 1910—							
Electric power plant						486,096.82	
Ancon rock quarry						709,398.86	
Chame sand plant						254,796.57	
Total						1,450,292.25	
Total Pacific division						15,007,324.52	

EXHIBIT B.

TABLE 1.—*Detailed cost per cubic yard, from January to June, 1910, inclusive.*

DRY EXCAVATION.

	Quantity.	Clearing.	Mining.	Loading.	Tracks.	Transportation.	Dumps.	Pumps.	Maintenance of equipment.	Contract cost.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total cost.
Gatun spillway.	*Cubic yards.*														
January	24,580		$0.0346	$0.2051	$0.0328	$0.1730		$0.0636	$0.0743		$0.1058	$0.0193	$0.7085	$0.1343	$0.8428
February	20,490		.0820	.3357	.1301	.3218		.0518	.1293		.1054	.0181	1.1742	.0916	1.2658
March	23,810		.0989	.2014	.0309	.1499		.0213	.1336		.1054	.0223	.7637	.0762	.8399
April	10,890		.1434	.3810	.0916	.1606		.0218	.1297		.1054	.0691	1.1026	.0886	1.1912
May															
June															
Total for 6 months	79,770		.0808	.2615	.0653	.2026		.0423	.1137		.1055	.0267	.8984	.0998	.9982
Gatun spillway foundations.															
January	510			6.1261		.1723			.1054			.2887	6.6925	1.3615	8.0540
February	1,730		.0496	2.4202		.1429			.1988		.1054	.1860	3.1029	.4528	3.5557
March	1,528			4.8637		.2919			.1820		.1054	.4184	5.8614	.7676	6.6290
April	370			.3015		.2868			.1023		.1065	.0479	.8450	.0581	.9031
May															
June	585			.8670					.0075			.1215	.9960	.1026	1.0986
Total for 6 months	4,723		.0182	3.2526		.1879			.1406		.0924	.2534	3.9451	.5785	4.5236
Gatun locks.															
January	91,418		.1093	.0944	.1430	.1181		.0147	.0508		.1054	.0218	.6575	.1253	.7828
February	97,905		.0970	.0934	.1791	.1335		.0077	.0103		.1054	.0203	.6467	.0659	.7126
March	101,780		.1227	.0858	.1237	.1350		.0289	.0477		.1054	.0268	.6760	.0648	.7408
April	86,790		.0937	.0765	.1342	.1362		.0186	.0733		.1054	.0253	.6632	.0387	.7019
May	76,473		.0526	.0327	.1475	.1497		.0273	.1188		.1054	.0423	.6763	.0601	.7364
June	82,343		.0666	.0613	.1123	.2237		.0542	.0638		.1054	.0517	.7390	.0611	.8001
Total for 6 months	536,709		.0924	.0758	.1404	.1477		.0246	.0582		.1054	.0306	.6751	.0699	.7450

TABLE 1.—*Detailed cost per cubic yard, from January to June, 1910, inclusive*—Continued.

DRY EXCAVATION—Continued.

	Quantity.	Clearing.	Mining.	Loading.	Tracks.	Transportation.	Dumps.	Pumps.	Maintenance of equipment.	Contract cost.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total cost.
Gatun locks foundations.	*Cubic yards.*														
January	8,503		$0.2413	$1.0375		$0.1181			$0.0452		$0.1054	$0.0560	$1.6035	$0.3144	$1.9179
February	3,613		.3282	3.2080		.1140			.1540		.1054	.2461	4.1557	.8313	4.9870
March	4,889		.2527	1.1301		.1704			.0816		.1054	.1359	1.8761	.3578	2.2339
April	5,193		.5984	1.3017		.1367			.4659		.1054	.2114	2.8195	.3479	3.1674
May	6,485		.8083	1.1715		.1271			.1926		.1054	.2235	2.6284	.3745	3.0029
June	5,160		.7572	1.4900		.2708			.0741		.1054	.3261	3.0236	.3355	3.3591
Total for 6 months	33,843		.4943	1.4178		.1531			.1593		.1054	.1849	2.5148	.3957	2.9105
Central division—Prism.															
January	1,467,462	$0.0592	.0995	.0677	$0.1237	.0971	$0.0607	$0.0027	.1060		.1300	.0405	.6687	.0500	.7187
February	1,512,419		.0882	.0633	.0631	.0863	.0523	.0026	.0618		.1300	.0181	.6057	.0542	.6599
March	1,964,291	.0006	.0784	.0496	.0756	.0782	.0433	.0023	.0657		.1300	.0116	.5353	.0367	.5720
April	1,694,769	.0012	.1171	.0525	.1084	.0956	.0511	.0048	.0731		.1300	.0124	.6462	.0414	.6876
May	1,332,062	.0003	.1075	.0660	.1366	.1172	.0655	.0140	.0948		.1300	.0142	.7461	.0508	.7969
June	1,453,289	.0012	.1273	.0591	.1064	.0992	.0616	.0082	.0731		.1300	.0165	.6826	.0521	.7347
Total for 6 months	9,424,292	**.0087**	.1019	.0589	.1130	.0944	.0454	.0054	.0812		.1300	.0184	.6399	.0468	.6867
Central division—Prism, contract.															
January	32,033									$0.3500	.1300		.4800		.4800
February	33,063									.3500	.1300		.4800		.4800
March	30,283									.3500	.1300		.4800		.4800
April	22,853									.3500	.1300		.4800		.4800
May	16,191									.3512	.1300		.4812		.4812
June	16,241									.3500	.1300		.4800		.4800
Total for 6 months	150,664									.3501	.1300		.4801		.4801
Total dry excavation	9,574,956												.6373	.0461	.6834
Pacific division—Prism.															
January															
February	10,084			.1177	.2763	.0680		.0380	.0[illegible]		.1000	.0146	.6435	.0554	.6989

March	22,860			.1349	.2947	.0658		.0331	.1199		.1000	.0179	.7663	.0686	.8349
April	34,309			.0950	.1480	.0543	.0254	.0263	.0053		.1000	.0166	.4709	.0568	.5277
May	20,964			.1188	.1272	.0654	.0681	.0287	.0143		.1000	.0331	.5556	.0557	.6113
June	11,486			.2057	.1900	.1453	.2127	.0461	.0704		.1000	.0273	.9975	.1201	1.1176
Total for 6 months	99,703			.1242	.1950	.0712	.0475	.0318	.0434		.1000	.0214	.6345	.0664	.7009
Pedro Miguel locks.															
January	23,520		.1534	.2032	.3937	.1351	.0271	.0836	.1342		.0838	.0425	1.2566	.1516	1.4082
February	3,076		**.0161**	.5663	.5746	.0698	.0586	.0475	.7230		.0804	.0598	2.1639	.2418	2.4057
March															
April															
May															
June															
Total for 6 months	26,596		.1375	.2414	.4146	.1276	.0308	.0795	.2023		.0834	.0445	1.3616	.1620	1.5236
Pedro Miguel locks foundations.															
January	3,800		1.7199	1.8326	.1018	.1361	.0863		.1565		.0800	.1882	4.3014	.5686	4.8700
February	6,410		1.1509	1.2841	.0698	.5745		.0475	**.0169**		.0803	.1105	3.3007	.2916	3.5923
March	6,784		1.0272	1.3923	.2923	.0719	.0337		.2312		.0809	.1306	3.2601	.2547	3.5148
April	9,129		.5478	1.0758	.1417	.1123		.0267	.0751		.0811	.1123	2.1728	.2744	2.4472
May	10,405		.6758	1.0548	.1203	.1268		.0291	.0523		.0800	.1597	2.2988	.1294	2.4282
June	8,420		.6680	1.2060	.1141	.1617	.2410	.0469	.0893		.0800	.1659	2.7729	.6302	3.4031
Total for 6 months	44,948		.8574	1.2368	.1407	.1867	.0575	.0278	.0898		.0804	.1422	2.8193	.3319	3.1512
Miraflores locks.															
January	31,479		.2754	.1707	.4106	.1176		.0272	.0677		.1000	.0321	1.2013	.1376	1.3389
February	14,779		.2237	.1498	.1926	.3404	.0855	.1281	.1815		.1000	.0321	1.4337	.1209	1.5546
March	543			.2937	.4635	.0799		.6917	.2233		.1000	.0551	1.9072	.2133	2.1205
April	1,383			3.1859	.2051	.0384		.1602	.0189		.1000	.0830	3.7915	.6412	4.4327
May	700			1.5300	.1009	.2260		.0457	.0935		.1000	.1801	2.2762	.3034	2.5796
June															
Total for 6 months	48,884		.2450	.2717	.3350	.1839	.0258	.0691	.1028		.1000	.0360	1.3693	.1503	1.5196
Miraflores locks, foundations.															
January															
February	71		45.7481	3.8900							.1000	2.0272	51.7653	5.3775	57.1428
March	11,711		.6998	.4744	.5898	.0800	.1398		.1723		.1000	.0795	2.3356	.3080	2.6436
April	10,710		.9995	.5073	.4469	.1335		.1047	.0219		.1000	.1061	2.4199	.3627	2.7826
May	19,550		.5866	.4341	.2422	.1033		.0543	.0216		.1000	.0915	1.6336	.1053	1.7389
June	21,994		.4253	.4418	.1567	.0945		.1096	.0585		.1000	.0659	1.4523	.2512	1.7035
Total for 6 months	64,036		.7281	.4403	.3104	.1009	.0256	.0717	.0618		.1000	.0881	1.9469	.2491	2.1969

TABLE 1.—*Detailed cost per cubic yard, from January to June, 1910, inclusive*—Continued.

DRY EXCAVATION—Continued.

	Quantity.	Clearing.	Mining.	Loading.	Tracks.	Transportation.	Dumps.	Pumps.	Maintenance of equipment.	Contract cost.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total cost.
Miraflores locks, diversions.	*Cubic yards.*														
January															
February	450												$0.5975		$0.5975
March	4,990												.3026		.3026
April	445												.5614		.5614
May															
June															
Total for 6 months	5,885												.3448		.3448
Miraflores dam and spillway.															
January															
February															
March															
April	550			$0.4299							$0.1100	$0.0051	.5450	$0.0176	.5626
May															
June															
Total for 6 months	550			.4299							.1100	.0051	.5450	.0176	.5626

NOTE.—When excavated material is used in filling for necessary works, the expense of dumping is charged to the work benefited. Excavation costs are charged with the expense of dumping when the material is wasted.

TABLE 2.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive.*

DREDGING EXCAVATION.

	Quantity.	Total of all dredges.			Tugs, clapets, barges, etc. [a]			Mining.	Operation, small boats.	Other repairs.	Dikes.	Clearing.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total cost.
		Operation.	Repairs.	Total.	Operation.	Repairs.	Total.										
Atlantic division—Prism.	*Cubic yards.*																
January	510,055	$0.0434	$0.0262	$0.0696	$0.0746	$0.0225	$0.0971	$0.0025	$0.0049	$0.0034	....	....	$0.0614	$0.0050	$0.1816	$0.0329	$0.2145
February	493,448	.0436	.0276	.0712	.0634	.0703	.1337	.0017	.0019	.0019	....	$0.0016	.0614	.0085	.2093	.0400	.2493
March	412,325	.0430	.0590	.1020	.0510	.0339	.0849	.0047	.0032	.0011	$0.0132	.0011	.0614	.0091	.2419	.0298	.2717
April	190,574	.0544	.2174	.2718	.1017	.0325	.1342	.0183	.0086	.0027	.0481	.0016	.0614	.0418	.5885	.0753	.6638
May	447,578	.0378	.0498	.0876	.0806	.0359	.1165	.0148	.0035	.0043	.0100	.0007	.0543	.0155	.2287	.0278	.2565
June	458,021	.0389	.0427	.0816	.0927	.1023	.1950	.0264	.0038	.0004	.0008	.0006	.0614	.0171	.2551	.0187	.2738
Total for 6 months	2,512,001	.0424	.0536	.0960	.0754	.0485	.1239	.0105	.0039	.0022	.0078	.0008	.0601	.0132	.2496	.0335	.2831
Pacific division—Prism.																	
January	518,936	.0533	.0262	.0795	.0706	.0276	.0982	.0193	.0042	.0055	....	.0061	.0900	.0060	.2574	.0253	.2827
February	285,791	.0610	.1077	.1687	.0667	.0243	.0910	.0457	.0062	.0015	....	.0070	.0995	.0098	.4266	.0185	.4451
March	462,588	.0519	.0575	.1094	.0546	.0122	.0668	.0400	.0026	.0139	....	.0040	.0900	.0073	.3123	.0270	.3393
April	534,322	.0482	.0271	.0753	.0612	.0273	.0885	.0238	.0020	.0156	....	.0104	.0897	.0066	.2686	.0252	.2938
May	484,509	.0493	.0427	.0920	.0645	.0232	.0877	.0363	.0031	.0071	....	.0092	.0900	.0108	.2892	.0194	.3086
June	475,486	.0475	.0129	.0604	.0736	.0557	.1293	.0368	.0028	.0063	....	.0047	.0900	.0072	.2637	.0292	.2929
Total for 6 months	2,761,632	.0512	.0407	.0919	.0645	.0269	.0914	.0323	.0033	.0088	....	.0070	.0909	.0078	.2929	.0245	.3174

Detailed cost per cubic yard of dredging excavation, by classes of dredges.

	Seagoing suction dredges.				Ladder dredges.				Dipper dredges.			
	Quantity.	Operation.	Repairs.	Total.	Quantity.	Operation.	Repairs.	Total.	Quantity.	Operation.	Repairs.	Total.
Atlantic division.	*Cubic yards.*				*Cubic yards.*				*Cubic yards.*			
January	327,360	$0.0343	$0.0051	$0.0394	163,380	$0.0524	$0.0578	$0.1102	19,315	$0.1224	$0.1146	$0.2370
February	267,840	.0383	.0098	.0481	168,547	.0492	.0365	.0857	57,061	.0520	.0849	.1369
March	188,790	.0317	.0485	.0802	179,135	.0494	.0767	.1261	45,400	.0649	.0337	.0986
April	....	....	....	....	162,974	.0509	.0303	.0812	27,600	.0469	.2256	.2725
May	301,320	.0295	.0127	.0422	146,258	.0546	.0552	.1098	....	....	....	....
June	310,029	.0293	.0100	.0401	130,994	.0532	.1070	.1602	16,998	.1042	.1285	.2327
Total for 6 months	1,395,339	.0331	.0366	.0696	950,288	.0515	.0592	.1107	166,374	.0684	.1647	.2331
Pacific division.												
January	271,767	.0461	.0067	.0528	219,778	.0524	.0335	.0859	27,391	.1328	.1742	.3070
February	39,152	.1233	.4704	.5937	218,089	.0408	.0345	.0753	28,550	.1301	.1697	.2998
March	149,959	.0560	.0906	.1466	262,759	.0415	.0342	.0757	49,870	.0945	.0803	.1748
April	261,350	.0393	.0059	.0452	251,905	.0498	.0471	.0969	41,067	.0961	.0494	.1455
May	259,991	.0301	.0038	.0419	178,230	.0520	.0916	.1436	46,288	.1023	.0737	.1760
June	271,079	.0357	.0062	.0419	166,807	.0561	.0151	.0712	37,600	.0943	.0511	.1454
Total for 6 months	1,253,298	.0444	.0300	.0744	1,277,568	.0481	.0420	.0901	230,766	.1053	.0909	.1962

a Unit costs under "Tugs, clapets, barges, etc.," based on yardage of dipper and ladder dredges. The seagoing suction dredges carry their material to the dumps.

TABLE 3.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive.*

MASONRY.

	Concrete.						Large rock.		Quantity.	Concrete.	Large rock.	Forms.	Placing.	Reenforcements.	Pumps.	Power.	Maintenance of equipment.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total.
	Quantity.	Cement.	Stone.	Sand.	Mixing.	Total.	Quantity.	Unit cost.														
ATLANTIC DIVISION.																						
Gatun spillway.	*Cubic yards.*						*Cubic yards.*		*Cubic yards.*													
January	2,586	$1.8883	$2.4622	$0.9183	$0.7461	$6.0149	......	......	2,586	$6.0149	......	$1.9799	$1.0360	......	$0.2016	......	$0.4225	$0.6164	$0.1072	$10.3785	$0.9727	$11.3512
February	6,588	2.1724	2.7208	.8827	.3612	6.1371	......	......	6,588	6.1371	......	.3853	.6068	......	.0538	......	.1898	.6164	.0699	8.0591	.2274	8.2865
March	9,797	1.9962	2.5182	.5659	.3554	5.4357	......	......	9,797	5.4357	......	.4593	.4249	......	.0488	......	.1264	.6164	.0771	7.1886	.1726	7.3612
April	8,358	2.0157	2.0586	.4852	.3297	4.8892	......	......	8,358	4.8892	......	.5284	.7882	......	.0267	......	.1635	.6164	.1623	7.1747	.4426	7.6173
May	3,167	1.9120	2.4433	.6070	.7910	5.7533	......	......	3,167	5.7533	......	.4658	1.7038	......	......	......	.7287	.6164	.3375	9.6055	.8615	10.4670
June	2,305	1.8620	2.3178	.6167	.6995	5.4960	284	$4.4261	2,589	4.8931	$0.4855	.6389	.8865	......	......	......	.3325	.6164	.3269	8.1798	.4586	8.6384
Total for 6 months	32,801	2.0105	2.4160	.6443	.4471	5.5179	284	4.4261	33,085	5.4706	.0380	.5955	.7592	......	.0477	......	.2453	.6164	.1440	7.9167	.4026	8.3193
Gatun locks.																						
January	54,136	1.8813	2.3279	.9084	.2389	5.3565	......	......	54,136	5.3565	......	.4675	.4835	......	.0249	$0.0864	.1467	.6035	.0615	7.2305	.3254	7.5559
February	55,696	2.2438	2.7583	.7932	.2795	6.0748	......	......	55,696	6.0748	......	.6681	.5827	......	.0135	.0673	.1763	.6035	.1148	8.3010	.3869	8.6879
March	59,241	1.9830	2.4011	.7175	.2583	5.3599	1,757	2.1021	60,998	5.2056	.0606	.5116	.4896	......	.0482	.0740	.2136	.6035	.0978	7.3045	.2129	7.5174
April	60,770	1.9515	2.2685	.6552	.3031	5.1783	2,457	2.4430	63,227	4.9771	.0949	.4593	.4862	$0.0009	.0255	.0839	.2034	.6035	.1267	7.0614	.4021	7.4635
May	71,979	1.9358	2.0922	.7862	.2208	5.0350	2,294	5.1731	74,273	4.8794	.1598	.4504	.3349	.0310	.0281	.0659	.2405	.6035	.1141	6.9076	.5035	7.4111
June	85,124	1.9194	2.1276	.7272	.1904	4.9646	4,277	2.6873	89,401	4.7272	.1286	.4558	.2929	.0229	.0499	.0642	.1889	.6035	.1076	6.6415	.2813	6.9228
Total for 6 months	386,946	1.9786	2.3038	.7602	.2438	5.2864	10,785	3.0652	397,731	5.1431	.0831	.4952	.4282	.0111	.0332	.0726	.1971	.6035	.1051	7.1722	.3523	7.5245

TABLE 3.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive*—Continued.

MASONRY—Continued.

	Concrete.						Large rock.														
	Quantity.	Cement.	Stone.	Sand.	Mixing.	Total.	Quantity.	Unit cost.	Quantity.	Concrete.	Large rock.	Forms.	Placing.	Reenforcements.	Pumps.	Power.	Maintenance of equipment.	Plant-arbitrary.	Division expenses.	Total division cost.	General expenses.	Total.
PACIFIC DIVISION.																					
Pedro Miguel locks.	*Cubic yards.*						*Cubic yards.*		*Cubic yards.*												
January	16,273	$1.5642	$1.1407	$0.4377	$0.4309	$3.5735	......	......	16,273	$3.5735	......	$0.8643	$0.8415	......	$0.0828	$0.1354	$0.0615	$0.4560	$0.1172	$6.1322	$0.5874	$6.7196
February	13,218	2.1168	1.4908	.4183	.7309	4.7568	......	......	13,218	4.7568	......	.8437	.7956	$0.0123	.0475	.1334	.0662	.4557	.0932	7.2044	.6501	7.8545
March	18,324	1.7710	1.5260	.4579	.8216	4.5765	469	$1.6225	18,793	4.4623	$0.0405	.8798	.8185	......	.0337	.0757	.1637	.4558	.1107	7.0408	.4649	7.5057
April	24,208	1.8583	1.4225	.4618	.4317	4.1743	314	.3425	24,522	4.1208	.0044	.5899	.4147	......	.0267	.1024	.0672	.4580	.0830	5.8671	.3250	6.1921
May	29,190	1.9578	1.0930	.3524	.2966	3.6998	386	.9439	29,576	3.6515	.0124	.5591	.3414	.0041	.0291	.1100	.0584	.4581	.1105	5.3346	.2105	5.5451
June	30,141	1.8023	1.0964	.4872	.3004	3.6863	490	.7486	30,631	3.6272	.0120	.5813	.3608	.0027	.0468	.0940	.1103	.4567	.0754	5.3672	.3300	5.6972
Total for 6 months.	131,354	1.8449	1.2609	.4354	.4559	3.9971	1,659	.9642	133,013	3.9473	.0120	.6808	.5331	.0028	.0418	.1055	.0880	.4569	.0965	5.9647	.3849	6.3496
Miraflores locks.																					
January	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
February	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
March	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
April	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
May	27	12.7159	2.5778	.6577	2.7000	18.6514	......	......	27	18.6514	......	7.2933	6.9838	......	......	......	......	.3300	1.0430	34.3015	1.7574	36.0589
June	1,603	1.7959	.8467	.3818	1.0847	4.1091	......	......	1,603	4.1091	......	1.7012	.3362	......	.1006	......	.1250	.3300	.1592	6.8613	.6963	7.5576
Total for 6 months.	1,630	1.9769	.8753	.3864	1.1114	4.3500	......	......	1,630	4.3500	......	1.7939	.4463	.0772	.0989	......	.1229	.3300	.1738	7.3930	.7200	8.1130

TABLE 4.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive.*

DRY FILLING.

	Quantity.	Tracks.	Trestles.	Transportation.	Filling.	Clearing site.	Maintenance of equipment.	Plant, arbitrary.	Division expenses.	Total division cost.	Administration and general expenses.	Total cost.
Gatun dam.	*Cubic yards.*											
January	236,994	$0.0714	$0.0333	$0.0531	$0.0972		$0.0025	$0.0548	$0.0085	$0.3208	$0.0489	$0.3697
February	271,788	.0442	.0225	.0761	.0776		.0009	.0548	.0100	.2861	.0362	.3223
March	332,661	.0299	.0354	.0492	.0365		.0040	.0548	.0032	.1422	.0186	.1608
April	263,437	.0453	.0253	.0581	.0509	$0.0696	.0058	.0548	.0148	.3246	.0201	.3447
May	194,868	.0522	.0204	.0157	.0646	.0749	.0069	.0548	.0152	.3047	.0261	.3308
June	258,653	.0568	.0147	.1167	.0596	.0333	.0033	.0548	.0219	.3611	.0216	.3827
Total for 6 months	1,558,401	.0485	.0107	.0630	.0627	.0267	.0037	.0548	.0118	.2819	.0280	.3099
Gatun dam—Paving.												
January												
February												
March												
April												
May	9,407				.1493			.0548	.0175	.2216	.0260	.2476
June	12,630				.1949			.0548	.0160	.2657	.0135	.2792
Total for 6 months	22,037				.2178			.0548	.0166	.2892	.0189	.3081
Gatun-Mindi levee.												
January												
February												
March	47,946	.1450	.2440	.0209	.1634	.0259		.0438	.0763	.7193	.0908	.8101
April	21,233				.1331	.0481		.0548	.0264	.2624	.0321	.2945
May	27,900	.0009	.0005		.1323			.0548	.0156	.2041	.0233	.2274
June	28,923	.0326	.0033	.0080	.0927			.0548	.0173	.2087	.0151	.2238
Total for 6 months	126,002	.0628	.0937	.0098	.1352	.0180		.0506	.0409	.4110	.0486	.4596

TABLE 4.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive*—Continued.

DRY FILLING—Continued.

	Quantity.	Tracks.	Trestles.	Transportation.	Filling.	Cleaning site.	Maintenance of equipment.	Plant, arbitrary.	Division expenses.	Total division cost.	Administration and general expenses.	Total cost.
Gatun locks, foundation.	*Cubic yards.*											
January												
February												
March												
April	1,731		$0.2547		$0.1000							$0.3547
May	14,677		.0020		.0615							.0635
June	1,475		.1412		2.3112							2.4524
Total for 6 months	17,883		.3424		.2508							.5932
Pedro Miguel dam.												
January												
February	11,510	$0.0995		$0.0680	.0592	$0.0017	$0.0290	$0.1000	$0.0081	$0.3655	$0.0250	.3905
March	22,860	.0658		.0667	.0423		.0377	.1000	.0095	.3220	.0373	.3593
April	31,394	.0830		.0500	.0656		.0347	.1000	.0112	.3445	.0383	.3828
May	23,572	.1174		.0665	.0786		.0450	.1000	.0258	.4333	.0435	.4768
June	1,350	.2729		.0801	.4177		.1503	.1000	.0548	1.0758	.2396	1.3154
Total for 6 months	90,686	.0925		.0612	.0676	.0024	.0391	.1000	.0148	.3776	.0407	.4183
Miraflores dam.												
January	28,151	.0504		.0428	.0535			.1100	.0097	.2664	.0273	.2937
February	1,438			.0722	.0228		.0307	.1100	.0042	.2399	.0123	.2522
March	5,385	.0728			.0256		.0417	.1100	.0053	.2554	.0205	.2759
April												
May	6,480	.0482		.0883	.0425		.0493	.1100	.0167	.3550	.0281	.3831
June	7,356	.0201		.1260	.0775		.0308	.1100	.0107	.3751	.0548	.4299
Total for 6 months	48,810	.0550		.0576	.0581		.0167	.1100	.0110	.3084	.0334	.3418

TABLE 5.—*Detailed cost per cubic yard, from January 1 to June 30, 1910, inclusive.*

HYDRAULIC FILLING.

	Quantities.	Dredging.	Relay pumps.	Pipe lines.	Wood flumes.	Power.	Small boats.	Maintenance of equipment.	Clearing.	Plant arbitrary.	Division expenses.	Total division cost.	General expenses.	Total cost.
Gatun dam.	*Cubic yards.*													
January	178,254	$0.1777	$0.0013	$0.0273	$0.0006	$0.0149	....	$0.0092	$0.0042	$0.0615	$0.0054	$0.3021	$0.0655	$0.3676
February	292,215	.1103	.0065	.0147	.0004	.0424	....	.0201	.0118	.0615	.0043	.2720	.0228	.2948
March	210,387	.0832	.0097	.0898	....	.0514	$0.0017	.1458	.1441	.0615	.0052	.5924	.0242	.6166
April	242,440	.0671	.0079	.0334	....	.0419	.0014	.0951	.0904	.0615	.0072	.4059	.0164	.4223
May	249,283	.0790	.0032	.0323	....	....	.0013	.0970	.0068	.0615	.0142	.2953	.0268	.3221
June	384,166	.0801	.0037	.0210	....	.0013	.0010	.0153	.0087	.0615	.0067	.1993	.0106	.2099
Total for 6 months	1,556,745	.0952	.0053	.0336	.0001	.0234	.0009	.0587	.0395	.0615	.0072	.3254	.0245	.3499

TABLE 6.—*Detailed cost per cubic yard from January 1 to June 30, 1910, inclusive.*

STONE PRODUCTION.

	Quantity.	Quarrying.									
		Stripping.	Drilling.	Blasting.	Loading.	Transportation.	Tracks.	Power.	Maintenance of equipment.	Plant arbitrary.	Total.
ATLANTIC DIVISION.											
Porto Bello quarry.	*Cu. yds.*										
January	59,122	$0.0248	$0.1454	$0.2833	$0.2402	$0.1387	$0.1039	$0.0620	$0.0607	$0.3401	$1.3991
February	61,136	.0534	.0983	.3361	.1661	.1277	.0763	.0461	.0652	.3401	1.3093
March	69,565	.0400	.1050	.3062	.1557	.1073	.0619	.0277	.0664	.3401	1.2103
April	71,968	.0376	.0694	.2588	.1520	.0943	.0580	.0318	.0534	.3401	1.0954
May	68,949	.0378	.0634	.2894	.1538	.1062	.0372	.0578	.0618	.3401	1.1475
June	74,184	.0218	.0557	.2999	.1065	.0860	.0334	.0462	.1501	.3401	1.1412
Total for 6 months	404,924	.0360	.0875	.2949	.1596	.1086	.0601	.0447	.0776	.3401	1.2091
PACIFIC DIVISION.											
Ancon quarry.											
January	....	....	....	....	....	....	....	....	....	....	....
February	23,281	.2777	.2353	.1282	.0988	.2262	.3264	....	.2035	.2300	1.7261
March	47,424	.1678	.1521	.0773	.0710	.1268	.2728	....	.1441	.2300	1.2419
April	39,204	.2077	.1447	.1434	.0712	.1352	.1313	....	.0239	.2300	1.0874
May	32,261	.0917	.1106	.0449	.0745	.1061	.0925	....	.0355	.2300	.7858
June	33,004	.1483	.0723	.0765	.0364	.1379	.0556	....	.0400	.2300	.7970
Total for 6 months	175,174	.1736	.1388	.0927	.0689	.1402	.1741	....	.0855	.2300	1.1038

	Crushing.						Total cost of production.	Quantity.	Towing.			
	Operation of crushers.	Stone bins and conveyors.	Power.	Maintenance of equipment.	Plant arbitrary.	Total.			Operation tugs and barges.	Maintenance of equipment.	Plant arbitrary.	Total.
ATLANTIC DIVISION.												
Porto Bello quarry.								*Cu. yds.*				
January	$0.0441	$0.0425	$0.0694	$0.0776	$0.1751	$0.4087	$1.8078	59,122	$0.2205	$0.1289	$0.2239	$0.5733
February	.0733	.0598	.0524	.0531	.1751	.4137	1.7230	61,136	.1953	.0968	.2240	.5161
March	.0586	.0327	.0346	.0394	.1751	.3404	1.5507	69,565	.1980	.0876	.2240	.5096
April	.0578	.0440	.0347	.0442	.1750	.3557	1.4511	71,968	.1420	.0262	.2240	.3922
May	.0597	.0374	.0526	.0407	.1751	.3655	1.5130	68,949	.1605	.0543	.2240	.4388
June	.0434	.0344	.0489	.0895	.1750	.3912	1.5324	74,184	.1076	.0231	.2240	.3547
Total for 6 months	.0559	.0413	.0481	.0573	.1751	.3777	1.5868	404,924	.1680	.0666	.2240	.4586
PACIFIC DIVISION.												
Ancon quarry.												
January	....	....	....	....	....	....	....	....	....	....	....	....
February	.0427	.0100	.0950	.0001	.0657	.2135	1.9396	....	....	....	....	....
March	.0330	.0081	.0492	.0006	.0649	.1558	1.3977	....	....	....	....	....
April	.0347	.0108	.0470	.0024	.0647	.1596	1.2470	....	....	....	....	....
May	.0341	.0080	.0452	.0001	.0645	.1519	.9377	....	....	....	....	....
June	.0314	.0080	.0424	.0134	.0651	.1603	.9573	....	....	....	....	....
Total for 6 months	.0346	.0089	.0528	.0033	.0649	.1645	1.2683	....	....	....	....	....

	Unloading.					Rail transportation.							Division expenses.	Total cost in storage.
	Operation cableways and cranes.	Maintenance of equipment.	Power.	Plant arbitrary.	Total.	Quantity.	Operation trains.	Maintenance of equipment.	Repairs to tracks.	Dumping in storage.	Plant arbitrary.	Total.		
ATLANTIC DIVISION.														
Porto Bello quarry.						*Cu. yds.*								
January	$0.1666	$0.0512	$0.0248	$0.1730	$0.4156	11,363	$0.3906	$0.1333	$0.1144	$0.0672	....	$0.7055	$0.0545	$2.9868
February	.3220	.0598	.0146	.1730	.5694	22,642	.1391	.0220	.0911	.0385	....	.2907	.0859	3.0019
March	.1638	.0681	.0162	.1730	.4211	19,566	.1702	.0414	.0005	.0941	....	.3062	.0892	2.6567
April	.1666	.0889	.0154	.1730	.4439	7,885	.3501	.1094	.0492	....	....	.5087	.0781	2.4211
May	.1200	.0784	.0141	.1736	.3861	1,074	1.9608	.7770	.1282	....	....	2.8660	.0926	2.4752
June	.0919	.0646	.0154	.1730	.3449	875	.5914	.1986	.3042	....	....	1.0942	.1064	2.3512
Total for 6 months	.1679	.0692	.0166	.1731	.4268	63,405	.2571	.0740	.0657	.0548	....	.4510	.0854	2.6283
PACIFIC DIVISION.														
Ancon quarry.														
January	....	....	....	....	....	....	....	....	....	....	....	....	....	....
February	....	....	....	....	....	23,281	.1409	.0712	....	.0193	$0.0500	.2814	.2540	2.1750
March	....	....	....	....	....	47,424	.0654	.0320	....	.0095	.0500	.1569	.0429	1.5975
April	....	....	....	....	....	39,204	.0663	.0281	.0469	.0180	.0500	.2093	.0457	1.5020
May	....	....	....	....	....	32,261	.0563	.0209	.0231	.0159	.0500	.1662	.0555	1.1594
June	....	....	....	....	....	33,004	.0591	.0145	.0330	.0091	.0500	.1657	.0332	1.1562
Total for 6 months	....	....	....	....	....	175,174	.0728	.0310	.0209	.0138	.0500	.1885	.0455	1.5023

NOTE.—Stone from Ancon quarry is transported direct by rail to storage pile and dumped from a trestle, hence there are no towing or unloading charges.

TABLE 7.—*Detailed cost per cubic yard, from January 1 to June 30, 1910, inclusive.*

SAND PRODUCTION.

	Excavation.									Dredging.									Towing.				Unloading.					Rail transportation.									
	Quantity.	Cleaning and blasting.	Loading.	Tracks.	Transportation.	Dumps.	Pumps.	Maintenance of equipment.	Total.	Quantity.	Operation dredges.	Maintenance of equipment.	Total.	Total quantity.	Production cost.	Plant arbitrary.	Total cost of production.	Total quantity.	Operation tugs and barges.	Maintenance of equipment.	Plant arbitrary.	Total.	Operation cableways and cranes.	Maintenance of equipment.	Power.	Plant arbitrary.	Total.	Quantity.	Operation trains.	Maintenance of equipment.	Repairs to tracks.	Dumping in storage.	Plant arbitrary.	Invoice from Pacific division.	Total.	Division expenses.	Total cost in storage.
ATLANTIC DIVISION.																																					
Nombre de Dios.	*Cu. yds.*									*Cu. yds.*				*Cu. yds.*				*Cu. yds.*										*Cu. yds.*									
January	4,364	$0.0018	$0.2534	$0.2260	$0.2275		$0.0254	$0.0748	$0.8089	11,382	$0.0927	$0.0280	$0.1207	15,746	$0.3114	$0.3871	$0.6985	15,746	$0.3020	$0.1794	$0.2310	$0.7124	$0.1162	$0.0420	$0.0195	$0.1239	$0.3016	4,831	$0.1664	$0.0568		$0.0286			$0.2518	$0.0630	$1.8527
February	18,400	.0189	.0520	.0706	.1404		.0056	.0586	.3461					18,400	.4080	.3871	.7951	18,400	.3402	.2878	.2310	.8590	.2772	.0532	.0140	.1239	.4683	4,021	.1391	.0220	$0.0670	.0384			.2671	.0707	2.2513
March	16,785	.0060	.1112	.0868	.1051	$0.0027	.0060	.1839	.5017	16,009	.1837	.1359	.3196	32,794	.4128	.3871	.7999	32,794	.3265	.1754	.2310	.7329	.1247	.0444	.0087	.1239	.3017	11,216	.0751	.0181	.0002	.0941			.1875	.0399	1.9387
April	19,535	.0058	.1016	.0323	.0676	.0074	.0099	.0554	.2800	13,474	.3740	.0823	.4563	33,069	.3518	.3871	.7389	33,069	.2271	.0838	.2310	.5419	.1240	.0910	.0149	.1239	.3538	8,057	.2308	.0768	.0771				.3847	.0465	1.7748
May	13,284	.0026	.1566	.0326	.1280	.0116	.0155	.1086	.4355	9,200	.4782	.1817	.6599	22,484	.5273	.3871	.9144	22,484	.2296	.0765	.2310	.5371	.1449	.1106	.0245	.1240	.4040	833	.5132	.2345	.0154				.7631	.0644	1.9479
June	10,644	.0058	.1514	.0949	.1112	.0149	.0419	.1808	.6009	15,707	.3934	.1819	.5753	26,351	.5857	.3871	.9728	26,351	.1890	.0260	.2310	.4460	.0968	.0858	.0260	.1239	.3325									.0865	1.8378
Total for 6 months	83,072	.0080	.1125	.0701	.1149	.0061	.0140	.1076	.4332	65,772	.3082	.1310	.4392	148,844	.4358	.3871	.8229	148,844	.2645	.1280	.2310	.6235	.1406	.0729	.0174	.1239	.3548	28,958	.1550	.0476	.0313	.0466			.2805	.0596	1.9154
PACIFIC DIVISION.																																					
Chame.																																					
January										23,613	.1482	.0270	.1752	23,613	.1752	.0300	.2052	23,613	.1062	.0708	.0600	.2370	.1136	.0171		.0925	.2232	9,433	.2016			.0139	.0700		.2855	.0130	.9639
February										27,400	.1739	.0356	.2095	27,400	.2095	.0300	.2395	27,400	.1171	.0242	.0600	.2013	.0845	.0088	.0292	.0932	.2157	18,805	.1454	.0521	.0014	.0467	.0692		.3148	.0183	.9896
March										30,746	.1360	.0961	.2321	30,746	.2321	.0300	.2621	30,746	.1397	.0632	.0600	.2629	.0855	.0343	.0331	.0961	.2490	26,161	.0627	.0361		.0137	.0685		.1810	.0235	.9785
April										29,876	.1039	.0945	.1984	29,876	.1984	.0300	.2284	29,876	.1355	.0204	.0600	.2159	.0970	.1139	.0276	.0951	.3336	22,383	.0579	.0255	.0407	.0208	.0656		.2105	.0286	1.0170
May										35,266	.0966	0.0181	.0785	35,266	.0785	.0300	.1085	35,266	.0862	.0567	.0600	.2029	.0765	.0618	.0398	.0973	.2754	21,155	.0547	.0209	.0316	.0265	.0649		.1906	.0344	.8198
June										36,292	.0859	.2948	.3807	36,292	.3807	.0300	.4107	36,292	.1133	.0595	.0600	.2328	.0623	.0658	.0205	.0945	.2431	18,448	.0542	.0113	.0431	.0142	.0592		.1820	.0371	1.1057
Total for 6 months										183,193	.1205	.0952	.2157	183,193	.2157	.0300	.2457	183,193	.1158	.0494	.0600	.2252	.0845	.0528	.0262	.0949	.2584	116,385	.0836	.0271	.0206	.0228	.0660		.2201	.0270	.9764
ATLANTIC DIVISION.																																					
Chame.																																					
January																												14,155	.2308	.0760		.0286	.1000	.7300	1.1054		
February																												8,595	.4365	.0500		.0385	.1000	.6800	1.3050		
March																												4,585	.3703	.0663		.0941	.1000	.8000	1.4397		
April																												7,493	.3005	.1329			.1000	.8100	1.3433		
May																												14,111	.1713	.0626			.1000	.8100	1.1439		
June																												17,844	.2012	.0508			.1000	.7300	1.0820		
Total for 6 months																												66,783	.2548	.0688		.0175	.1000	8077	1.2488		

NOTE.—Sand furnished the Atlantic division by the Pacific division was delivered from unloading bins at Balboa. "Total cost in storage" in Pacific division represents cost of quantity stored at Pedro Miguel and Miraflores.

APPENDIX I.

REPORT OF A. L. ROBINSON, SUPERINTENDENT, MECHANICAL DIVISION, DEPARTMENT OF CONSTRUCTION AND ENGINEERING.

Isthmian Canal Commission,
Department of Construction and Engineering,
Mechanical Division, Office of Superintendent,
Gorgona, Canal Zone, August 1, 1910.

Sir: In compliance with circular letter of June 24, I have the honor to herewith submit annual report covering operations of the mechanical division for the fiscal year 1909–10.

During the first three months of this fiscal year the mechanical division operated under the same organization as that maintained during the previous fiscal year. It was then recognized that by concentrating all manufacturing work and all repairs to rolling equipment other than steam shovels in one shop a greater economy in the operations of this division could be thus obtained. On September 17, 1909, your Circular No. 183–M was issued, which circular turned over the Empire shop to the central division, said shop to be used for the repair of steam shovels only and for the finishing of steam shovel parts.

All other repairs to rolling equipment and manufacturing work previously performed at Empire shop was transferred to Gorgona shop, including the maintenance and repairs of all steel cars.

Following the issuance of this circular, a general reorganization of the supervisory force of the mechanical division occurred. After the resignation of the superintendent of motive power and machinery the position of head of the mechanical division was filled by the electrical engineer and master mechanic of Gorgona shop, with the title of superintendent of the mechanical division. The former master mechanic of Empire shop was made superintendent of outside engine houses and air compressor plants, the position of chief boiler inspector was abolished, and the boiler inspection department and the testing department were placed directly under the supervision of the mechanical engineer. Later in the year other changes were made in the supervisory force of this division, which consisted in the abolishment of the position of superintendent of outside engine houses and air compressor plants, the foremen of engine houses reporting direct to the superintendent of the mechanical division, and the air compressor plants were placed under the jurisdiction of the superintendent of electric light plants. The position of master car builder was also abolished and the car inspection service was placed in the hands of a chief car inspector, reporting directly to the general foreman of the car and foundry department, Gorgona shop. In addition, general reorganization of clerical and drafting forces, as well as all supervisory forces, was effected, which resulted in very material decreases in the overhead expense of the mechanical division.

During the fiscal year 1908–9 the average overhead expense of the mechanical division was 37.29 per cent of the total expenditures, this overhead expense consisting of supervisory and shop expense only, and not including any moneys expended for new equipment, additions, or improvements, as such moneys were charged to an existing plant account. During the nine months' operation of the mechanical division under the reorganization, from October to June, inclusive, of the present fiscal year, the average overhead expense has been 29 per cent of the total expenditures. This overhead expense includes all supervisory expense, shop expense, and in addition, all moneys expended for improvements and new equipment, except for air compressor, electric light plant, and foundry equipment, the plant account having been abolished July 1, 1909. This saving in overhead expense amounts to approximately $105,000 per annum.

The organization of the mechanical division consisted on June 30, 1910, of the following: Superintendent, Mr. A. L. Robinson; mechanical engineer, Mr. J. H. Flynn, jr.; superintendent of electric light and air compressor plants, Mr. Hartley Rowe; chief clerk, Mr. William Taylor; chief draftsman, Mr. C. E. Whipple; testing engineer, Mr. Q. A. Hall.

GORGONA SHOP.

During the year few additions have been made to Gorgona shop, and such additions have been limited to only those necessary to care for the increased work thrown upon these shops by the reorganization of October 1, 1909.

LOCOMOTIVE DEPARTMENT.

[Mr. A. T. Corcoran, general foreman in charge.]

MACHINE SHOP.

A 79-inch wheel lathe, motor driven, transferred from the Empire shop, has been installed. A number of templates, gauges, boring bars, double end cutters, forming tools, special taps, special milling cutters, jigs, and fixtures have been manufactured; all to reduce the cost of manufactured material. That portion of the machine shop formerly used for casting storage has been devoted to an extension of the air brake room, and additional benches, test racks, and other facilities for the overhauling of engineer's brake valves, pumps, triple valves, lubricators, etc., have been installed; also a machine for the grinding of triple valves.

BLACKSMITH SHOP.

An extension of 1,440 additional square feet was made to the blacksmith shop. Three new oil furnaces, one Bradley hammer, one light shears for cutting bolts, two 300-pound cranes, one upsetting block, one 25-horsepower motor, and two jib cranes were installed. In addition, numerous dies and formers have been made to cheapen the manufacture of standard repair parts for cars. locomotives, etc.

PIPE AND TIN SHOP.

A "calorix" brazing furnace was installed for brazing large work.

BOILER SHOP.

The amount of structural iron and steel manufacturing work sent to these shops during the past year made the floor space of the boiler shop entirely inadequate. Changes were therefore authorized, which allowed the construction of a new steel storage yard back of the boiler shop, allowing the present storage yard, containing 9,000 square feet of floor space, to be used as part of the boiler shop proper. Construction of this storage yard necessitated the moving of approximately 4,000 cubic yards of dirt and the laying of approximately 1,780 linear feet of track. In addition, a template and pattern storage room 11 by 36 feet for storage of steel templates and patterns was erected. One angle-bar heating furnace for flange fire, 36 by 72 inches; one flange-fire forge, 54 by 84 inches; one punch, 12-inch throat; one punch, 18-inch throat; one Lennox bending clamp; one 1-ton jib crane; three pneumatic hoists; and two electric motors were installed. A large number of templates, forms, patterns, etc., for the manufacture of standard repair parts were also manufactured in this shop.

ENGINE ROOM.

One air compressor, 2,500 cubic feet per minute capacity, and one Worthington hot-water meter were installed.

CAR AND FOUNDRY DEPARTMENT.

[Mr. J. J. Eason, general foreman in charge. Mr. W. W. Hurley, chief car inspector.]

CAR SHOPS.

All repair work to flat cars and other rolling equipment formerly performed in the two car shops was concentrated on October 1, 1909, into the new car shop, the old car shop being used from that date for the repairs of steel dump cars, which repairs were formerly made at Empire shop. This change required the installing of blacksmith forges, a tool and stock room 22 by 60 feet, the overhauling and putting into service of a 10-ton French crane for handling side doors and other heavy parts of steel cars, and other minor accessories.

During the past year the car repair yards at Las Cascadas and Gamboa have been abolished, and the work formerly performed at these two points has been concentrated at Gorgona shop, with the desired resultant economy. Also the work performed at Pedro Miguel car yard has been cut down to only the making of the lightest running repairs, all cars requiring even medium repairs being sent to Gorgona shop.

With the abolishment of the position of master car builder, a reorganization of the car-inspection service was made, which resulted in cutting the field repair forces by some 45 "silver" men and at the same time put into effect a system whereby every car handling dirt is given a through inspection at least once each day.

PLANING MILL.

There has been transferred from Empire shop and installed in the planing mill one large car sill gainer.

CAR MACHINE SHOP.

There has been transferred from Empire shop and installed in the car machine shop one bolt cutter and two drill presses.

FOUNDRY AND PATTERN SHOP.

The foundry work at Gorgona has increased during this fiscal year until now the output of our foundry is approximately 65 per cent greater than in June, 1909. This increased output, together with the large number of patterns being manufactured and stored, required additional space for both the foundry and the pattern storage. A new pattern-storage building was therefore erected, 42 by 100 feet, two stories, with a total floor space of 8,200 square feet, together with all the necessary shelving. Some 16,000 patterns are now stored in this building, the value of which are estimated at between $150,000 and $200,000.

The old pattern-storage building was converted into a brass foundry, and there has been installed in same two No. 150 and one No. 60 Steel-Harvey crucible melting furnaces, which use oil as fuel. The brass foundry now has a capacity of 3,000 to 4,000 pounds of brass per eight-hour day, an increase of approximately 50 per cent over the old pit furnaces formerly occupying space in the iron foundry. One 1-ton jib crane, for handling large castings; one 5-horsepower motor; one emery wheel; and one tumbler and brass separator for cleaning brass castings are in process of installation in the new brass foundry. By the removal of the brass foundry to the new building and the addition of a lean-to 20 by 160 feet between power plant and the old foundry the floor space of the iron foundry was increased by about 4,160 square feet. Two 3-ton jib cranes have been installed and one 10-ton jib crane is under erection in the iron foundry.

ENGINE HOUSES.

This division maintains ouside engine houses at the following points for the purpose of hostling and making running repairs to equipment:

Pedro Miguel engine house; general foreman in charge, Mr. J. J. Bartley.

Las Cascadas and Gamboa engine houses; general foreman in charge, Mr. E. B. Connor.

Tabernilla engine house; foreman in charge, Mr. D. E. Hall.

At these points during the past year there were handled 63,278 hostlings to locomotives, 6,417 hostlings to other equipment, a total of 69,695 hostlings, at a labor cost of $74,281.56, material, $12,843.67, a total of $87,125.23. The average labor cost for the year for all hostling points was $1.065 per unit hostled.

MECHANICAL ENGINEER'S DEPARTMENT.

With the reorganization, the office of the mechanical engineer was removed from the Culebra general offices to Gorgona shop, this move producing much more efficient results in that the mechanical engineer's force was brought into closer contact with actual shop operation.

All requests for articles to be manufactured at Gorgona shop, whether accompanied by drawings or not, are referred to the mechan-

ical engineer, where they are checked for proportion and design for the most economical method of manufacture. This department ascertains whether the necessary material for manufacture is in stock, and if shortages occur arrange for the substitution of other stock material to facilitate the prompt completion of the manufactured article. Detail shop drawings are made for the individual shops before shop order is issued. Detail of all repair parts for all new equipment are prepared and shop orders issued for the manufacture of such repair parts as it is considered advisable to prepare on the Isthmus, while requisitions are issued for such repair parts as it is considered advisable to order in the States. Standard specifications for all classes of material are prepared for the purchasing department and, in addition, all requisitions for stock material pertaining to any mechanical appliances are forwarded by the quartermaster's department to this division for check. Records of all equipment in service and condemned, together with condition of same, are maintained, and other general work such as pertains to the mechanical engineer's department of a manufacturing plant is performed.

BOILER-INSPECTION SERVICE.

The boiler-inspection service, as a branch of the mechanical engineer's department, consists of four boiler inspectors, who make regular inspections and reports of all boilers in service on the Isthmus for both the commission and the Panama Railroad Company. All inspections are made in conformance with the rules and regulations for boiler inspection as approved by the chief engineer, records of same being kept and the heads of divisions and departments duly notified of the condition of boilers in the several departments.

TESTING DEPARTMENT.

The testing department as a branch of the mechanical engineer's department has made during the past year 637 tests. These tests are of a wide variety and nature, but consist mainly in the testing of various classes of material, such as belting, cables, coal, grease, hose, lubricating oils, etc. Also efficiency tests upon various plants, which tests have unquestionably resulted in materially assisting in obtaining fuel economies. Tests were also made upon the boiler plants of the Miraflores and Gatun power plants to determine the efficiencies of boilers in those plants and to ascertain whether they came within the specified contract efficiencies. Also the testing of fuel oils for percentage of water and sediment, upon which fuel oil a rebate is paid to the commission for all water and sediment in same in excess of 2 per cent.

ELECTRIC-LIGHT AND AIR-COMPRESSOR SUBDIVISION.

This division continued the operation of all electric lights on the Isthmus, amounting to approximately 31,000 lights, as well as the furnishing of 1,338,997 kilowatt-hour metered current for the operation of motors, arc lights, etc. During this year they installed a 5½-mile, 6,600-volt, 3-phase pole line between Gatun and Cristobal; installed a complete fire-alarm system in Gatun; took over from the Panama Railroad Company all of their lighting system in Cristobal and Colon, and reconstructed all pole lines and accessories taken from the Panama Railroad Company. All lights in Cristobal and Colon had been formerly operated by two small belt sets installed in the

cold-storage plant of the Panama Railroad Company. During the past year these two generators were replaced by two 200-kilowatt-hour frequency changer sets, operated from current brought from Gatun power plant over the above-mentioned 6,600-volt pole line. An entire remodeling of the electrical engine room of the cold-storage plant was made, and all necessary switchboards and other apparatus for the operation of frequency changers were installed. In addition, one 35-horsepower motor for wireless station, Colon; one 35-horsepower motor for Colon sewerage sump; and one 35-horsepower motor for sawmill, Mount Hope, were installed. During this year the price of lights as operated for all divisions has been reduced to 50 cents per month per lamp, and to 4 cents per kilowatt-hour for current on meter basis. The revenue derived from this operation pays for the maintenance of all pole lines, lamp renewals, building wiring repairs, and in addition covers the expense of all new installations, such as the above-mentioned frequency changers, switchboards, etc.

AIR-COMPRESSOR PLANTS.

The air-compressor subdivision has generated during the past year 7,227,203,513 cubic feet of free air, as against 4,935,110,000 cubic feet for the preceding fiscal year, an increase of 46 per cent.

One additional 2,500 cubic feet capacity compressor has been installed in the Empire plant, and one 2,500 cubic feet capacity compressor has been installed in the Rio Grande plant.

All compressor plants have been equipped with hot-water meters, fuel-oil heaters, and other accessories for keeping close accounting of the output per barrel of fuel oil, of water evaporated from and at 212 degrees per barrel of oil, and the general economies of plant operation.

Eighteen thousand eight hundred and ten feet of main pipe line have been removed and rebuilt on account of slides occurring through "Culebra cut." Also 3,600 feet of 8-inch main installed between Balboa plant and Ancon rock-crushing plant.

Prior to July 1, 1909, all additions and improvements to air-compressor plants were charged to a plant account. Since that date all additions, improvements, and reconstructions are charged in operating expense. Yet the cost of air generation per 1,000 cubic feet in June, 1910, was 0.0339 cent, as against 0.037 cent in June, 1909.

I attach hereto statements as follows covering the operations of this division for the year:

Exhibit A.—Abstract of expenditures.
Exhibit B.—Number and class of repairs to all locomotives, and cost of same.
Exhibit C.—Number and class of repairs to all cars, and cost of same.
Exhibit D.—Operation of the brass and the iron foundries for the year.
Exhibit E.—Output of the air-compressor plants, with cost for each month of the year.
Exhibit F.—Operation of the electric-light plants.
Exhibit G.—Number of repairs made to all classes of equipment other than locomotives and cars.
Exhibit H.—Number of employees on the pay rolls at the close of each month and the average for the year.

Respectfully submitted.

A. L. Robinson,
Superintendent.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.

EXHIBITS ACCOMPANYING REPORT OF SUPERINTENDENT MECHANICAL DIVISION.

EXHIBIT A.—*Abstract of expenditures, 1909–1910.*

Month.	Labor.	Material.	O. D. service.	Total.
1909.				
July	$159,896.09	$116,647.84	$8,524.54	$285,068.47
August	154,623.74	129,190.71	9,615.88	293,430.33
September	151,176.29	122,403.59	9,864.52	283,444.40
October	127,193.53	108,130.09	4,160.21	239,483.83
November	123,450.45	116,303.33	7,632.29	247,386.07
December	127,827.69	103,095.98	9,741.85	240,665.52
1910.				
January	128,561.54	109,592.63	8,278.77	246,432.94
February	122,970.68	115,345.80	6,539.35	244,855.83
March	131,412.60	112,300.15	9,425.52	253,138.27
April	127,816.47	107,758.82	7,095.61	242,670.90
May	123,386.42	129,890.48	9,139.95	262,416.85
June	122,275.38	96,996.92	7,222.59	226,494.89
Total	1,600,590.88	1,367,656.34	97,241.08	3,065,488.30

EXHIBIT B.—*Number of repairs to locomotives.*

Month.	Running repairs.	Heavy or general repairs.	Total.
1909.			
July	1,822	31	1,853
August	1,792	29	1,821
September	1,610	28	1,638
October	1,667	36	1,703
November	1,428	28	1,456
December	1,606	29	1,635
1910.			
January	1,828	26	1,854
February	1,908	20	1,928
March	1,968	16	1,984
April	1,893	15	1,908
May	1,965	20	1,985
June	1,998	22	2,020
Total	21,485	300	21,785

	Labor.	Material.	Total.
Cost of repairs to locomotives	$233,836.43	$90,294.38	$324,130.81
Average cost per month	19,486.37	7,524.53	27,010.90
Average cost per locomotive (286 locomotives in service)	817.61	315.72	1,133.33

EXHIBIT C.—*Number of repairs to all classes of cars.*

Class.	Heavy.	Light.	Field.	Total.
40-ton flats	1,563	31,291	62,904	95,758
Western dumps	414	853	22,469	23,736
Oliver dumps	339	592	15,506	16,437
Ingoldsby dumps	19	14	62	95
Goodwin dumps	3	13	29	45
Steel flats	14	31	389	434
Miscellaneous	26	121	563	710
Total	2,378	32,915	101,922	137,215

	Labor.	Material.	Total.
Repairs to freight cars	$376,571.21	$352,282.92	$728,854.13
Average per month	31,380.93	29,356.91	60,737.84

EXHIBIT D.—*Operation of the brass and the iron foundries.*

Month.	Iron foundry output.		Brass foundry output.		Brass patterns made.	Brass castings made.	Iron patterns made.	Iron castings made.	Total patterns.	Total castings.[a]
	Castings.	Cost per pound.	Castings.	Cost per pound.						
1909.										
July	277,869	$0.0330	22,031	$0.1512	22	1,547	119	8,573	141	10,120
August	351,192	.0285	34,382	.1476	30	2,277	90	6,154	120	8,431
September	280,666	.0295	33,161	.1492	35	2,808	69	4,960	104	7,768
October	286,796	.0320	23,192	.1728	11	1,664	98	7,037	109	8,701
November	369,648	.0290	16,783	.1814	31	1,782	84	7,160	115	8,942
December	438,551	.0265	19,190	.1742	29	1,287	101	6,291	130	7,578
1910.										
January	466,830	.0272	31,334	.1710	26	1,911	142	5,449	168	7,360
February	464,939	.0288	27,567	.1713	24	1,457	181	7,607	205	9,064
March	494,312	.0291	24,777	.1697	36	2,694	111	10,351	147	13,045
April	450,744	.0286	42,583	.1937	43	3,902	119	12,445	162	16,347
May	419,661	.0383	55,857	.1918	46	2,662	148	19,400	194	22,062
June	519,554	.0246	63,138	.1722	39	3,195	205	18,278	244	21,473
Total	4,820,762	.0293	393,995	.1723	372	27,186	1,467	113,705	1,839	140,891
Totals for year 1908-9.	4,586,342	[b] .0276	333,416	[b] .1572	359	....	1,080	....	1,439	....

[a] The expense of making and caring for patterns is included in cost of castings.
[b] Did not include plant expense.

The above costs are without surcharge.

EXHIBIT E.—*Output of air-compressor plants.*

Month.	Cubic feet.	Cost.	Cost per 1,000 cubic feet.
1909.			
July	530,345,000	$20,635.82	$0.0389
August	566,856,000	18,827.60	.0332
September	548,660,000	22,301.05	.0406
October	624,847,555	26,209.78	.0419
November	602,054,020	25,890.58	.0430
December	611,743,979	24,991.06	.0409
1910.			
January	616,734,869	24,015.17	.0389
February	555,348,958	21,127.85	.0380
March	627,795,019	23,258.60	.0370
April	618,234,751	23,995.30	.0388
May	663,507,960	37,664.86	[a] .0567
June	661,075,402	22,456.35	.0339
Total	7,227,203,513	291,374.02	.0403

[a] Includes cost of two new compressors.

Exhibit F.—*Operation of electric-light plants.*

Month.	Kilowatt hour output, mechanical division plants.	Kilowatt hour output, Cristobal and Gatun plants, as accepted by mechanical division for billing.
1909.		
July	341,437	....
August	346,143	....
September	340,268	....
October	368,256	[a] 39,809
November	387,692	78,353
December	388,960	88,816
1910.		
January	365,555	70,421
February	340,774	82,415
March	354,238	91,187
April	361,299	103,867
May	379,537	141,861
June	368,091	130,802
Total	4,342,250	827,531

	16-candlepower lights or equivalent.	Arc lights.
June, 1909	23,592	139
June, 1910	30,818	194

[a] Cristobal only.

Exhibit G.—*Repairs to equipment other than locomotives and cars.*

Month.	Cranes.	Track shifters.	Unloaders.	Spreaders.	Others.	Total.
1909.						
July	26	18	103	64	3	214
August	25	15	73	36	19	168
September	31	15	88	54	38	226
October	32	14	65	48	35	194
November	26	10	72	32	37	177
December	19	8	62	37	47	173
1910.						
January	17	5	35	27	40	124
February	20	14	77	38	18	167
March	29	13	69	40	17	168
April	25	9	74	43	18	169
May	20	17	67	39	21	164
June	24	16	75	42	34	191
Total	294	154	860	500	327	2,135

EXHIBIT H.—*Number of employees on pay rolls at close of each month.*

Month.	Gold.	Silver.	Total.
1909.			
July	916	1,236	2,152
August	952	1,374	2,326
September	952	1,351	2,303
October	785	1,183	1,968
November	787	1,294	2,081
December	793	1,214	2,007
1910.			
January	771	1,276	2,047
February	778	1,311	2,089
March	784	1,310	2,094
April	759	1,222	1,981
May	753	1,181	1,934
June	748	1,141	1,889
Total	9,778	15,093	24,871
Average	815	1,258	2,073

APPENDIX J.

REPORT OF C. M. SAVILLE, ASSISTANT ENGINEER, IN CHARGE OF THE THIRD DIVISION OF THE OFFICE OF THE CHIEF ENGINEER.

ISTHMIAN CANAL COMMISSION,
THIRD DIVISION, OFFICE OF THE CHIEF ENGINEER,
Culebra, Canal Zone, July 29, 1910.

SIR: I have the honor to submit the following report of operations of the third division of the office of the chief engineer during the fiscal year ended June 30, 1910.

For convenience in carrying on its work the division has been subdivided into several sections under the direction of the following assistants:

Clerical.—Mr. D. W. MacCormack, chief clerk.

Meteorological.—Mr. F. D. Willson, principal observer.

Hydrographic.—Mr. Malcolm Elliott, principal hydrographer to January 1, 1910; Mr. H. F. French, principal hydrographer (acting) since January 1, 1910.

General surveys and explorations.—Mr. R. R. Wiggins, junior engineer, in charge of field work; Mr. Malcolm Elliott, assistant engineer, in charge of computations and office work.

METEOROLOGY.

STATIONS AND EQUIPMENT.

Three first-class stations are in operation—Ancon, Culebra, and Cristobal—with the following equipments: Standard mercurial barometer, standard exposed hygrometer, anemoscope, anemometer, sunshine recorder, tipping-bucket rain gauge, and the following self-recording instruments: Meteorograph, recording wind movement, velocity, and direction, sunshine and rainfall; thermograph, hygrograph, and water-and-air thermograph. The Culebra station is equipped with one solar chronometer and a maximum solar thermometer for recording direct-sun temperature.

Twenty rainfall stations are also maintained—9 supplied with the standard rain gauge and 11 with automatic registers of the tipping-bucket type. In addition, 4 automatic gauges of Dutch make, requiring attention about three times a month, are located in the headwaters of the Pedro Miguel, Chilibre, Cano Quebrada, and Siri Grande rivers. Records of rainfall are received from Chepo and Chorrera, Republic

de Panama, and from Bocas del Toro through the courtesy of the United Fruit Company.

Besides the regular meterological stations, two wind-movement stations are maintained, one at Pedro Miguel and the other at Gatun.

Evaporation stations are maintained at Ancon, Cristobal, Rio Grande Reservoir, and Brazos Brook Reservoir. Continuous tidal records are kept at Cristobal and Balboa.

TEMPERATURE.

The annual temperature for the calendar year 1909 was below the normal, the average being 78° at Cristobal and Culebra and 79° at Ancon. The following table shows the maximum and minimum temperatures of record at the first-class stations:

Absolute temperatures of record.

Station.	Maximum.		Minimum.	
	Date.	°F.	Date.	°F.
Ancon	Mar. 20, 1908	96	Jan. 27, 1910	63
Culebra	Apr. 15, 1909	94	Mar. 21, 1910	61
Cristobal	June 3, 1909	92	Dec. 3, 1909	66

NOTE.—The lowest temperature recorded on the Isthmus since American records have been kept was 59° at Bas Obispo on February 9, 1907.

The absolute maximum temperature in the sun registered at Culebra since records have been kept was 105° on May 15, 1909.

RAINFALL.

The precipitation for the calendar year 1909 exceeded the station averages at all stations and established a new maximum at Balboa, Pedro Miguel, Rio Grande, Camacho, Alhajuela, San Pablo, Tabernilla, Trinidad, Gatun, Brazos Brook, and Cristobal.

The rainfall for the year 1909 at Porto Bello, 237.28 inches, was the heaviest of record on the Isthmus.

The heaviest rainfall for one calendar month also occurred at this station, 58.17 inches falling in December, 1909. The November, 1909, rainfall at Porto Bello was 45.03 inches, exceeding the previous high record of 43.01 inches at Cristobal in November, 1862.

The heaviest rainfall of record for twenty-four consecutive hours occurred at Porto Bello, 10.86 inches falling in the twenty-four hours ending at 10 a. m., December 29, 1909. The previous high record was 10.48 inches at Gatun in December, 1906.

The heaviest rainfall for one hour was 4.90 inches on October 6, 1909, at Cristobal, exceeded but once since American occupation of the Zone at Balboa on June 2, 1906, when the gauge showed 5.86 inches for that period. New records for one hour were also established at Gatun, where 3.82 inches fell on May 26, 1910, and at Alhajuela, where 3.23 inches fell on May 28, 1910.

Hail fell at Alhajuela on the afternoon of May 28, 1910. A similar phenomenon is said to have occurred at Cucaracha some two years ago.

HUMIDITY.

There was an increase in the average relative humidity. (See Table 7.)

The lowest relative humidity of record on the Isthmus was 24 per cent, registered at Culebra on March 20, 1910.

WIND.

There was a deficiency of wind movement during the year.

During a storm at Ancon on July 10, 1909, the wind attained a maximum velocity for one minute of 70 miles an hour and for five minutes of 59 miles an hour, which are the greatest velocities of record on the Isthmus.

EVAPORATION.

Records of evaporation from land and water surfaces have been made at the two stations at Rio Grande and Brazos Brook reservoirs, and much valuable information on this important factor in the water supply of Gatun Lake is now available. These data are obtained from copper tanks 4 feet in diameter. There are two of these at each station, one floating in an exposed position in the lake, and the other on land, exposed as nearly as possible to the same conditions as the floating tank.

Records of the evaporation are also obtained from insulated tanks 10 inches in diameter, protected from the direct rays of the sun, but otherwise exposed, located at Ancon and Cristobal.

The total monthly evaporation at the various stations in the Canal Zone is shown in Table 5, and a graphic representation of the evaporation and allied phenomena at Brazos Brook and Rio Grande reservoirs is given on Plates 129 and 130.

FOGS.

A record of the duration and intensity of fogs along the canal prism was continued at eight stations and is shown in Table 6.

OCEAN METEOROLOGY.

Data are being collected, through the cooperation of the various steamship companies touching at Balboa and Cristobal, regarding the weather conditions, set and velocity of ocean currents, temperature of the surface water, periodic occurrence of tropical storms, etc., and later are expected to be compiled into a synoptic chart for the benefit of vessels approaching or departing from either entrance of the canal.

SEISMOLOGY.

Slight seismic disturbances have been of frequent occurrence during the year, very few of which, however, were physically observed in the Zone. (See Tables 8 and 9.)

The seismological records at Ancon have been continuous during the year, and, except in cases of minor local tremors, harmonize with the records of the instruments in the United States, Mexico, and Europe. The effect on the seismographs of blasting is being carefully studied, the kind and amount of explosives used and the character of the blast and locality being noted.

TIDES.

The tidal conditions on the Atlantic and Pacific coasts are shown in the following table and in Tables 10 and 11:

Tidal extremes (revised to June 30, 1910).

	Balboa.		Cristobal.[a]	
	Feet.	Date.	Feet.	Date.
Absolute range (maximum)	+11.2	Oct. 2, 1909	+1.65	Nov. 27, 1909
	−10.4	Mar. 23, 1909	−1.01	June 9, 1910
Maximum amplitude	20.6	Oct. 2, 1909	1.97	Dec. 27, 1909
Absolute range (minimum)	+ 2.3	Feb. 4, 1910	....	....
	− 2.1	Oct. 19, 1909	....	....
Minimum amplitude	5.6	Mar. 6, 1910	....	....

[a] One tidal fluctuation often entirely absent.

REPORTS AND DATA ISSUED.

A general meteorological summary for the Canal Zone, covering the calendar year 1909 and the fiscal year ended June 30, 1910, is shown in Table 7.

A weather report has been compiled daily containing the meteorological conditions, air pressure, temperature, relative humidity, wind movement, and weather at 8 a. m., and the maximum temperatures, rainfall, and evaporation for the previous twenty-four hours.

A monthly meteorological summary is made up containing daily and monthly maximum, minimum, and mean temperatures, evaporation, precipitation, temperature of sea water, weather conditions, air pressure, wind direction and velocity, and miscellaneous phenomena, such as auroras, halos, fogs, thunderstorms, earthquakes, and tidal waves.

The following diagrams accompany the report of this section:

Plate 125.—Rainfall along the canal prism.
Plate 126.—Comparative monthly distribution of rainfall.
Plate 127.—Wind roses showing mean hourly velocity and direction during dry season of 1909.
Plate 128.—Wind roses showing mean hourly velocity and direction during wet season of 1909.
Plate 129.—Evaporation and allied phenomena—Brazos Brook reservoir.
Plate 130.—Evaporation and allied phenomena—Rio Grande reservoir.

The following tables accompanying the report of this section are appended:

Table 1.—Rainfall on the Isthmus of Panama. Accumulated monthly averages.
Table 2.—Distribution of rainfall on Canal Zone, showing hourly periods of maximum and minimum precipitation.
Table 3.—Excessive rainfall in Canal Zone. Maximum amounts of record to June 30, 1910.
Table 4.—Minimum rainfall for consecutive periods from one month to nineteen years.
Table 5.—Evaporation in the Canal Zone.
Table 6.—Fogs at various stations.
Table 7.—Meteorological summary for Canal Zone, calendar year 1909 and year ended June 30, 1910.
Table 8.—Bosch-Omori seismograph records.
Table 9.—Bosch-Omori seismograph records.
Table 10.—Balboa tides, 1909.
Table 11.—Cristobal tides, 1909.

TABLE 1.—*Rainfall on the Isthmus of Panama, January, 1909, to June, 1910, inclusive—Accumulated monthly averages.*

Station and years of record.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.
Ancon:																								
1909	2.90	2.90	2.90	5.80	0.18	5.98	2.92	8.90	9.10	18.00	9.90	27.90	9.01	36.91	6.84	43.75	3.86	47.61	8.77	56.38	15.14	71.52	12.39	83.91
1910	1.22	1.22	.43	1.65	1.83	3.48	3.71	7.19	9.89	17.08	8.82	25.90	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (12 years)	1.11	1.11	.78	1.89	.81	2.70	2.36	5.06	8.55	13.61	8.68	22.29	8.10	30.39	7.30	37.69	7.70	45.39	10.55	55.94	11.46	67.40	3.92	71.32
Balboa:																								
1909	1.45	1.45	1.69	3.14	.14	3.28	2.83	6.11	9.69	15.80	12.06	27.86	14.92	42.78	6.86	49.64	4.11	53.75	11.20	64.95	15.99	80.94	12.12	93.06
1910	.97	.97	.46	1.43	2.16	3.59	3.63	7.22	8.88	16.10	10.44	26.54	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (13 years)	1.31	1.31	.36	1.67	.87	2.54	3.95	6.49	6.78	13.27	8.20	21.47	10.22	31.69	7.24	38.93	6.47	45.40	9.05	54.45	10.15	64.60	6.14	70.74
Miraflores:																								
1909	4.18	4.18	1.81	5.99	1.11	7.10	2.30	9.40	8.75	18.15	18.31	36.46	10.27	46.73	6.46	53.19	11.85	65.04	17.53	82.57	22.43	105.00	14.53	119.53
1910	3.58	3.58	2.02	5.60	2.49	8.09	5.15	13.24	10.39	23.63	13.79	37.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Pedro Miguel:																								
1909	3.08	3.08	3.26	6.34	.59	6.93	2.32	9.25	8.50	17.75	14.19	31.94	9.19	41.13	10.07	51.20	10.22	61.42	17.47	78.89	20.38	99.27	11.30	110.57
1910	1.82	1.82	.50	2.32	1.46	3.78	5.86	8.94	13.24	22.18	14.42	38.60	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (2 years)	1.54	1.54	1.63	3.17	6.34	3.51	1.74	5.25	11.62	16.87	10.95	27.82	9.36	37.18	9.69	46.87	8.89	55.76	12.94	68.70	14.52	83.22	10.78	94.00
Rio Grande:																								
1909	3.85	3.85	2.88	6.73	.18	6.91	2.63	9.54	7.32	16.86	9.27	26.13	8.13	34.26	9.12	43.38	11.23	54.61	18.52	73.13	24.17	97.30	10.56	107.86
1910	1.65	1.65	1.00	2.65	1.69	4.34	5.36	9.70	10.96	20.66	11.69	32.35	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (5 years)	1.81	1.81	.63	2.44	.17	2.61	2.59	5.20	10.46	15.66	10.47	26.13	11.28	37.41	10.47	47.88	11.51	59.39	12.79	72.18	11.42	83.60	6.25	89.85
Culebra:																								
1909	2.96	2.96	2.46	5.42	.15	5.57	2.56	8.13	7.36	15.49	9.44	24.93	7.95	32.88	8.32	41.20	8.40	49.60	17.70	67.30	24.46	91.76	10.58	102.34
1910	1.31	1.31	.93	2.24	1.36	3.60	5.35	8.95	10.50	19.45	11.16	30.61	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (18 years)	1.95	1.95	.54	2.49	.71	3.20	3.70	6.90	11.16	18.06	9.05	27.11	9.31	36.42	10.60	47.02	11.42	58.44	11.25	69.69	12.60	82.29	8.00	90.29
Camacho:																								
1909	3.29	3.29	2.16	5.45	.40	5.85	2.64	8.49	9.34	17.83	10.52	28.35	8.68	37.03	8.03	45.06	13.01	58.07	20.63	78.70	27.07	105.77	10.54	116.31
1910	2.00	2.00	1.39	3.39	2.36	5.75	6.92	12.67	12.05	24.72	12.11	36.83	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (3 years)	1.70	1.70	.72	2.42	.31	2.73	1.59	4.32	10.67	14.99	12.06	27.05	10.52	37.57	10.12	47.69	11.23	58.92	12.84	71.76	15.09	86.85	7.51	94.36
Empire:																								
1909	2.28	2.28	1.50	3.78	.21	3.99	3.33	7.32	7.73	15.05	7.84	22.89	8.27	31.16	7.20	38.36	7.22	45.58	21.14	66.72	20.99	87.71	9.44	97.15
1910	.70	.70	.75	1.45	1.60	3.05	4.24	7.29	11.08	18.37	10.14	28.51	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (6 years)	1.10	1.10	.55	1.65	.31	1.96	3.53	5.49	9.21	14.70	8.31	23.01	9.76	32.77	10.15	42.92	7.76	50.68	14.48	55.16	12.62	77.18	6.20	83.38
Gamboa:																								
1909	2.77	2.77	4.07	6.84	.56	7.40	5.55	12.95	15.37	28.32	9.55	37.87	11.59	49.46	7.03	56.49	7.90	64.39	16.98	81.37	28.41	109.78	12.33	122.11
1910	1.24	1.24	1.80	3.04	3.12	6.16	3.85	10.01	11.09	21.10	12.08	33.18	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (28 years)	2.02	2.02	.81	2.83	.79	3.62	3.61	7.23	10.88	18.11	9.64	27.75	10.19	37.94	12.26	50.20	10.55	60.75	12.77	73.52	12.38	85.90	7.09	92.99

TABLE 1.—*Rainfall on the Isthmus of Panama, January, 1909, to June, 1910, inclusive—Accumulated monthly averages*—Continued.

Station and years of record.	January.		February.		March.		April.		May.		June.		July.		August.		September.		October.		November.		December.	
	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.	Current month.	Accumulated.
Gorgona:																								
1909	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11.16	.....	8.45	.....	8.84	.....	18.90	.....	30.24	.....	12.82	.....
1910	1.60	1.60	1.79	3.39	2.98	6.37	5.79	12.16	8.06	20.22	12.91	33.13	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
San Pablo:																								
1909	4.09	4.09	1.76	5.85	.46	6.31	5.50	11.81	9.00	20.81	10.80	31.61	10.63	42.24	9.04	31.28	12.17	63.45	15.81	79.26	27.59	106.85	12.10	118.95
1910	2.21	2.21	2.87	5.08	4.47	9.55	6.52	16.07	9.93	26.00	10.38	36.38	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (3 years)	2.44	2.44	.92	3.36	.48	3.84	4.44	8.28	10.17	18.45	10.77	29.22	10.18	39.40	10.24	49.64	11.66	61.30	15.90	77.20	15.81	93.01	6.63	99.64
Tabernilla:																								
1909	4.58	4.58	2.87	7.45	.99	8.44	6.30	14.74	10.07	24.81	11.16	35.97	10.78	46.75	9.78	56.53	13.10	69.63	17.02	86.65	30.84	117.49	13.59	131.08
1910	2.26	2.26	2.19	4.45	5.44	9.89	6.29	16.18	9.15	25.33	10.15	35.48	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (3 years)	2.75	2.75	1.61	4.36	.86	5.22	4.34	9.56	12.43	21.99	10.78	32.77	13.14	45.91	10.71	56.62	12.82	69.44	19.35	88.79	17.50	106.29	7.22	113.51
Bohio:																								
1909	7.29	7.29	3.74	11.03	3.66	14.69	7.23	21.92	13.69	35.61	12.31	47.92	11.07	58.99	10.01	69.00	10.43	79.43	16.34	95.77	35.39	131.16	20.53	151.69
1910	4.02	4.02	6.89	10.91	6.60	17.51	6.46	23.97	14.14	38.11	11.75	49.86	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (15 years)	6.55	6.55	1.79	8.34	1.76	10.10	5.80	15.90	13.92	29.82	12.51	42.33	12.87	55.20	15.38	70.58	13.84	84.42	16.94	101.36	19.21	120.57	10.58	131.15
Trinidad:																								
1909	7.58	7.58	4.27	11.85	3.08	14.93	6.96	21.89	10.79	32.68	14.86	47.54	10.78	58.32	9.50	67.82	13.64	81.46	14.58	96.04	33.28	129.32	18.49	147.81
1910	4.28	4.28	5.97	10.25	8.18	18.43	9.28	27.71	11.12	38.83	11.11	49.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (2 years)	5.15	5.15	2.57	7.72	2.52	10.24	5.18	15.42	14.60	30.02	11.86	41.88	8.62	50.50	14.25	64.75	13.22	77.97	13.58	91.55	23.74	115.29	12.86	128.15
Monte Lirio:																								
1909	7.94	7.94	5.69	13.63	4.85	18.48	7.18	25.66	9.29	34.95	12.36	47.31	15.63	62.94	8.39	71.33	9.87	81.20	13.38	94.58	34.73	129.31	24.08	153.39
1910	4.29	4.29	8.93	13.22	9.57	22.79	7.01	29.80	11.84	41.64	16.30	57.94	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (2 years)	5.36	5.36	3.54	8.90	3.78	12.68	5.40	18.08	15.92	34.00	13.42	47.42	14.30	61.72	12.14	73.86	8.88	82.74	13.46	96.20	30.15	126.35	11.67	138.02
Gatun:																								
1909	7.17	7.17	4.12	11.29	2.99	14.28	4.03	18.31	8.98	27.29	16.35	43.64	11.46	55.10	9.92	65.02	10.86	75.88	15.55	91.43	41.10	132.53	31.66	164.19
1910	4.81	4.81	3.33	8.14	9.08	17.22	4.97	22.19	15.68	37.87	11.41	49.28	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (4 years)	4.74	4.74	2.27	7.01	2.37	9.38	3.38	12.76	15.34	28.10	13.88	41.98	12.34	54.32	16.66	70.98	10.55	81.53	17.09	98.62	23.63	122.25	15.14	137.39
Brazos Brook:																								
1909	9.10	9.10	4.13	13.23	2.90	16.13	6.23	22.36	7.51	29.87	18.63	48.50	12.23	60.73	10.67	71.40	9.66	81.06	14.82	95.88	38.17	134.05	36.45	170.50
1910	4.03	4.03	3.30	7.33	9.71	17.04	5.59	22.63	11.27	33.90	11.86	45.76	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (3 years)	5.15	5.15	2.07	7.22	2.63	9.85	2.88	12.73	12.14	24.87	16.08	40.95	16.32	57.27	15.66	72.93	12.34	85.27	15.40	100.67	25.71	126.38	16.92	143.30
Cristobal:																								
1909	10.61	10.61	1.92	12.53	1.85	14.38	3.56	17.94	7.21	25.15	17.49	42.64	12.83	55.47	15.42	70.89	16.33	87.22	19.31	106.53	42.50	149.03	34.38	183.41
1910	2.94	2.94	3.58	6.52	5.46	11.98	3.30	15.28	12.09	27.37	13.63	41.00	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Average (39 years)	4.16	4.16	1.40	5.56	1.60	7.16	4.21	11.37	12.31	23.68	13.22	36.90	16.38	53.28	15.23	68.51	12.57	81.08	14.11	95.19	21.80	116.99	12.51	129.50

Alhajuela:																								
1909	2.72	2.72	3.71	6.43	.29	6.72	3.54	10.26	14.32	24.58	19.73	44.31	13.64	57.95	8.15	66.10	7.50	73.60	19.32	92.92	36.22	129.14	22.90	152.04
1910	2.99	2.99	2.58	5.57	2.74	8.31	2.99	11.30	11.50	22.80	13.62	36.42	......	......	......	......	......	......	......	......	......	......	......	......
Average (10 years)	1.28	1.28	.50	1.78	.58	2.36	3.38	5.74	12.45	18.19	13.08	31.27	13.57	44.84	13.28	58.12	11.41	69.53	13.36	82.89	14.68	97.57	7.36	104.93
El Vigla:																								
1909	3.91	3.91	4.88	8.79	.32	9.11	2.32	11.43	15.54	26.97	16.93	43.90	14.09	57.99	11.24	69.23	10.91	80.14	20.93	101.07	35.64	136.71	[a]10.90	147.61
1910	.68	.68	2.41	3.09	2.95	6.04	2.33	8.37	10.47	18.84	12.02	30.86	......	......	......	......	......	......	......	......	......	......	......	......
Bocas del Toro:																								
1909	......	......	24.94	......	5.24	......	6.12	......	3.77	......	6.06	......	8.63	......	6.17	......	4.83	......	3.76	......	......	......	26.43	......
1910	33.66	33.66	6.98	40.64	3.61	44.25	17.30	61.55	13.97	75.52	10.12	85.64	......	......	......	......	......	......	......	......	......	......	......	......
Porto Bello:																								
1909	20.90	20.90	6.82	27.72	3.56	31.28	12.56	43.84	9.69	53.53	17.70	71.23	26.33	97.56	13.83	111.39	13.99	125.38	8.70	134.08	45.03	179.11	58.17	237.28
1910	14.05	14.05	5.89	19.94	6.32	26.26	7.14	33.40	9.30	42.70	15.24	57.94	......	......	......	......	......	......	......	......	......	......	......	......
Average (2 years)	11.83	11.83	4.17	16.00	2.24	18.24	9.27	27.51	15.36	42.87	17.34	60.21	18.16	78.37	15.40	93.77	11.29	105.06	7.99	113.05	34.77	147.82	32.47	180.29
Nombre de Dios:																								
1909	15.26	15.26	8.64	23.90	1.43	25.33	12.58	37.91	8.11	46.02	18.02	64.04	16.94	80.98	12.15	93.13	7.72	100.85	18.17	119.02	25.62	144.64	36.04	180.68
1910	9.57	9.57	4.40	13.97	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Chorrera:																								
1909	......	......	......	......	......	......	......	......	4.58	......	6.19	......	6.57	......	5.42	......	2.46	......	......	......	42.89	......	......	......
Chefo:																								
1909	......	......	......	......	......	......	......	......	16.04	......	19.71	......	10.14	......	13.52	......	9.73	......	......	......	33.70	......	......	......
1910	1.09	1.09	1.41	2.50	1.11	3.01	3.13	6.74	13.93	20.67	10.35	31.02	......	......	......	......	......	......	......	......	......	......	......	......

[a] Station washed away by flood, December 26.

NOTE.—Years of record and averages are exclusive of 1910.

TABLE 2.—*Distribution of rainfall on the Canal Zone, calendar year 1909, showing hourly periods of maximum and minimum rainfall.*

Station.	Total rainfall.	Rainfall during working hours, 7 a. m.–5 p. m.		Maximum rainfall.		Minimum rainfall.	
		Amount.	Per cent of total.	Hour of maximum.	Accumulated amount.	Hour of minimum.	Accumulated amount.
	Inches.	*Inches.*			*Inches.*		*Inches.*
Cristobal	183.41	93.51	51	2 to 3 p. m.	15.83	12 to 1 a. m.	3.54
Bohio	151.69	95.89	63	do	19.86	3 to 4 a. m.	2.00
Culebra	102.34	65.74	64	1 to 2 p. m.	12.61	8 to 9 a. m.	.98
Pedro Miguel	110.57	74.79	68	do	16.53	1 to 2 a. m.	1.36
Balboa	93.06	48.44	52	3 to 4 p. m.	11.31	9 to 10 a. m.	1.25

TABLE 3.—*Excessive rainfall in Canal Zone, October 1, 1905, to June 30, 1910, arranged in periods of five minutes, one hour, and one day.*

Station.	Rainfall for—					
	Five minutes.		One hour.		One day.	
	Inches.	Date.	Inches.	Date.	Inches.	Date.
Ancon (Oct. 1, 1905)	0.64	Aug., 1908	2.89	Aug., 1908	3.18	June, 1907
Balboa (Dec. 29, 1906)	.63	Aug., 1908	5.86	June, 1906	7.31	Nov., 1906
Pedro Miguel (Jan. 1, 1908)	.60	Nov., 1908	3.30	Aug., 1908	4.15	Dec., 1908
Rio Grande (Dec. 29, 1906)	.75	July, 1908	2.57	Oct., 1907	5.58	Dec., 1906
Culebra (July 1, 1906)	.64	May, 1908	3.69	Oct., 1907	4.70	June, 1907
Empire (July 18, 1906)	.60	July, 1906	3.63	Oct., 1909	6.15	Dec., 1906
Bas Obispo (Nov. 1, 1906)	.53	Nov., 1907	3.14	Aug., 1907	4.53	Aug., 1907
San Pablo (Nov. 1, 1907)	.60	Oct., 1908	3.10	Oct., 1908	4.37	Nov., 1909
Tabernilla (Nov. 1, 1907)	.50	Oct., 1909	3.09	Aug., 1908	4.32	Nov., 1909
Bohio (Oct. 1, 1905)	.67	June, 1909	4.51	Aug., 1908	8.82	Aug., 1908
Gatun (Aug. 24, 1907)	.61	July, 1908	3.82	May, 1910	10.48	Dec., 1906
Cristobal (Oct. 1, 1905)	.64	Aug., 1909	4.90	Oct., 1909	8.47	Dec., 1906
Porto Bello (May 1, 1908)	.64	Aug., 1908	3.77	Aug., 1908	10.86	Dec., 1906
Alhajuela (Mar. 31, 1907)	.50	Oct., 1907	3.23	May, 1910	8.19	Dec., 1906

NOTE.—Dates in parentheses with station names refer to installation of automatic registers.

TABLE 4.—*Periods of minimum rainfall for consecutive periods and calendar months.*

	Cristobal.		Bohio.		Gamboa.	
	Amount.	Period.	Amount.	Period.	Amount.	Period.
	Inches.		*Inches.*		*Inches.*	
1 month	0.04	Feb., 1897	0.00	Feb., 1897	0.00	Feb., 1891, Mar., 1897, Mar., 1898.
2 months	.32	Feb. and Mar., 1907	.25	Feb. and Mar., 1897	.12	Feb. and Mar., 1898.
3 months	2.14	Feb., Mar., and Apr., 1900	2.14	Feb., Mar., and Apr., 1905	.73	Jan., Feb., and Mar., 1908.
4 months	4.00	Jan. to Apr., 1903, inclusive	5.13	Jan. to Apr., 1907, inclusive	1.36	Jan. to Apr., 1907, inclusive.
5 months	9.52	Dec., 1900, to Apr., 1901, inclusive	9.57	Dec., 1907, to Apr., 1908, inclusive	2.37	Dec., 1900, to Apr., 1901, inclusive.
6 months	15.71	Dec., 1900, to May, 1901, inclusive	20.95	Nov., 1907, to Apr., 1908, inclusive	13.24	Dec., 1900, to May, 1901, inclusive.
7 months	26.76	Dec., 1900, to June, 1901, inclusive	31.35	Dec., 1902, to June, 1903, inclusive	20.92	Dec., 1900, to June, 1901, inclusive.
8 months	36.70	Dec., 1900, to July, 1901, inclusive	42.05	Dec., 1902, to July, 1903, inclusive	29.23	Nov., 1897, to June, 1898, inclusive.
9 months	49.21	Dec., 1900, to Aug., 1901, inclusive	53.09	Dec., 1902, to Aug., 1903, inclusive	38.73	Dec., 1890, to Aug., 1891, inclusive.
10 months	61.09	Dec., 1900, to Sept., 1901, inclusive	66.16	Nov., 1902, to Aug., 1903, inclusive	48.65	Nov., 1890, to Aug., 1891, inclusive.
11 months	73.74	Dec., 1900, to Oct., 1901, inclusive	77.44	June, 1904, to Apr., 1905, inclusive	59.12	Nov., 1890, to Sept., 1891, inclusive.
1 year	94.02	Nov., 1900, to Oct., 1901, iuclusive	89.68	May, 1904, to Apr., 1905, inclusive	73.55	Dec., 1907, to Nov., 1908, inclusive.
2 years	216.63	Dec., 1900, to Nov., 1902, inclusive	191.36	June, 1904, to May, 1906, inclusive	150.69	May, 1899, to Apr., 1901, inclusive.
3 years	330.46	Apr., 1900, to Mar., 1903, inclusive	297.72	June, 1904, to May, 1907, inclusive	238.71	May, 1898, to Apr., 1901, inclusive.
4 years	441.38	Nov., 1899, to Oct., 1903, inclusive	396.50	May, 1904, to Apr., 1908, inclusive	320.63	Oct., 1897, to Sept., 1901, inclusive.
5 years	575.37	May, 1898, to Apr., 1903, inclusive	520.76	June, 1902, to May, 1907, inclusive	418.44	Feb., 1904, to Jan., 1909, inclusive.
6 years	707.37	Aug., 1898, to July, 1904, inclusive	621.20	May, 1902, to Apr., 1908, inclusive	513.81	Dec., 1902, to Nov., 1908, inclusive.
7 years	828.44	Aug., 1898, to July, 1905, inclusive	747.81	Feb., 1902, to Jan., 1909, inclusive	605.62	Feb., 1902, to Jan., 1909, inclusive.
8 years	942.91	Aug., 1898, to July, 1906, inclusive	934.23	Jan., 1901, to Dec., 1908, inclusive	697.28	Feb., 1898, to Jan., 1906, inclusive.
9 years	1,081.81	July, 1897, to June, 1906, inclusive	1,052.76	Apr., 1899, to Mar., 1908, inclusive	780.87	Nov., 1897, to Oct., 1906, inclusive.
10 years	1,209.03	June, 1896, to May, 1906, inclusive	1,181.52	Mar., 1899, to Feb., 1909, inclusive	861.92	Dec., 1898, to Nov., 1908, inclusive.
11 years	1,342.15	June, 1896, to May, 1907, inclusive	1,383.89	Feb., 1898, to Jan., 1909, inclusive	949.07	Jan., 1898, to Dec., 1908, inclusive.
12 years	1,480.41	May, 1896, to Apr., 1908, inclusive	1,558.70	Jan., 1907, to Dec., 1908, inclusive	1,056.40	Jan., 1897, to Dec., 1908, inclusive.
13 years	1,620.13	Nov., 1895, to Oct., 1908, inclusive				
14 years	1,776.24	Jan., 1895, to Dec., 1908, inclusive				
15 years	1,924.13	Jan., 1893, to Dec., 1907, inclusive				
16 years	2,058.16	Aug., 1892, to July, 1908, inclusive				
17 years	2,200.87	July, 1891, to June, 1908, inclusive				
18 years	2,331.84	Jan., 1891, to Dec., 1908, inclusive				
19 years	2,476.92	Nov., 1890, to June, 1908, inclusive				

TABLE 5.—*Evaporation in Canal Zone, January, 1907, to June, 1910, inclusive.*

Month.	1907, Bas Obispo.[a]	1908.			1909.					1910.			
		Ancon.[b]	Bas Obispo.[a]	Cristobal.[b]	Ancon.[b]	Rio Grande.[c]	Bas Obispo.[a]	Brazos Brook.[c]	Cristobal.[b]	Ancon.[b]	Rio Grande.[c]	Brazos Brook.[c]	Cristobal.[b]
January	5.175	3.348	5.617	4.868	3.348	....	3.240	....	4.868	4.354	4.672	4.622	5.257
February	5.072	6.557	5.729	7.958	3.728	....	4.295	....	5.353	5.350	5.529	4.668	4.574
March	6.538	6.997	6.290	7.557	4.931	....	5.005	....	6.445	6.190	6.003	6.151	6.500
April	6.486	5.921	5.475	6.930	3.883	5.690	4.710	5.366	6.467	4.379	3.986	5.025	5.209
May	4.681	3.219	3.175	2.570	2.451	4.205	3.517	4.597	3.868	3.378	3.916	4.304	3.493
June	3.125	2.046	3.415	3.184	1.916	3.417	3.284	3.806	2.498	2.666	2.654	3.516	2.703
July	3.152	3.017	3.250	2.822	2.080	3.117	....	3.042	2.445	....	....	....	....
August	3.582	3.203	3.425	3.192	2.271	3.353	....	3.760	2.636	....	....	....	....
September	3.358	3.049	3.635	3.327	2.484	3.768	....	4.169	2.727	....	....	....	....
October	2.938	3.256	3.875	3.324	2.826	3.094	....	4.168	3.027	....	....	....	....
November	3.599	2.414	2.730	2.700	2.332	2.713	....	2.152	1.950	....	....	....	....
December	4.896	2.942	3.445	4.056	3.020	2.993	....	2.379	2.746	....	....	....	....
Total	52.602	46.969	50.061	52.488	35.270	....	....	....	45.030	....	....	....	....

[a] Concrete tank 12½ feet in diameter.
[b] Insulated tank 10 inches in diameter.
[c] Tank 4 feet in diameter floating in reservoir.

TABLE 6.—*Fogs along the canal prism (calendar year 1909).*

Date.	Ancon.			Pedro Miguel.			Culebra.			Bas Obispo.			Bohio.			Gatun.			Cristobal.		
	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.	No.	Duration.	Mean time commenced.
		h. m.			*h. m.*			*h. m.*			*h. m.*			*h. m.*			*h. m.*			*h. m.*	
January	...	...	...	5	9 50	3 a. m.	14	70 20	8 a. m.	11	60 20	Midnight.	20	94 00	1 a. m.	3	12 00	Midnight.	1	4 30	3 a. m.
February	...	...	...	2	5 45	6 a. m.	7	26 35	4 a. m.	5	23 10	3 a. m.	9	17 20	6 a. m.	2	3 30	6 a. m.	...	...	...
March	...	...	...	...	...	...	14	62 45	2 a. m.	3	23 10	Midnight.	8	24 15	4 a. m.	4	10 55	5 a. m.	...	...	...
April	...	...	...	7	22 15	3 a. m.	27	128 10	2 a. m.	9	52 20	2 a. m.	14	41 30	4 a. m.	9	43 00	3 a. m.	1	35	7 a. m.
May	...	...	...	8	35 10	3 a. m.	26	165 45	2 a. m.	22	109 50	1 a. m.	18	52 20	4 a. m.	18	90 00	3 a. m.	...	...	...
June	...	...	...	12	50 30	4 a. m.	24	133 25	1 a. m.	18	63 00	1 a. m.	18	71 00	3 a. m.	23	217 00	2 a. m.	...	...	...
July	1	1 30	4 a. m.	9	21 45	4 a. m.	27	128 30	3 a. m.	20	99 00	1 a. m.	27	127 50	1 a. m.	22	97 20	2 a. m.	...	...	...
August	...	...	...	17	56 15	5 a. m.	25	109 30	1 a. m.	28	146 30	Midnight.	30	160 40	1 a. m.	30	144 20	1 a. m.	1	7 30	Midnight.
September	...	...	...	19	59 00	6 a. m.	25	122 00	1 a. m.	...	...	...	28	190 25	11 p. m.	25	140 05	1 a. m.	...	...	...
October	...	...	...	14	36 50	4 a. m.	19	85 05	1 a. m.	29	224 20	Midnight.	21	101 55	1 a. m.	28	169 45	1 a. m.	...	...	...
November	...	...	...	6	21 00	4 a. m.	13	70 45	3 a. m.	14	93 00	11 p. m.	12	79 25	Midnight.	9	49 00	1 a. m.	...	...	...
December	...	...	...	5	16 45	4 a. m.	19	72 50	3 a. m.	7	22 45	2 a. m.	5	29 10	1 a. m.	6	13 30	2 a. m.	...	...	...
Total	1	1 30	...	104	335 05	...	240	1,170 40	...	166	917 25	...	210	989 50	...	179	990 25	...	3	12 25	...
Means	...	1 30	4 a. m.	...	3 13	4.11 a. m.	...	4 53	2.35 a. m.	...	5 32	12.49 a. m.	...	4 43	2.05 a. m.	...	5 32	2.15 a. m.	...	4 12	3.20 a. m.

Percentage of fogs dissipated.

	Ancon.	Pedro Miguel.	Culebra.	Bas Obispo.	Bohio.	Gatun.	Cristobal.
Before 8 a. m.	100	98	89	94	96	95	100
Before 8.30 a. m.	100	100	99	100	99	98	100
Before 9 a. m.	100	100	100	100	100	99	100

TABLE 7.—*Meteorological summary, Canal Zone.*

CALENDAR YEAR 1909.

Station.	Annual mean reduced pressure.	Temperature.				Relative humidity.		Rainfall.		Sunshine (possible).		Total wind movement and prevailing direction.		
		Absolute maximum.	Absolute minimum.	Annual mean.	Annual mean daily range.	Dry season.	Wet season.	Dry season.	Wet season.	Dry season.	Wet season.	Dry season.	Wet season.	Maximum velocity.
	Inches.	° *F.*	° *F.*	° *F.*	° *F.*	*Per ct.*	*Per ct.*	*Inches.*	*Inches.*	*Per ct.*	*Per ct.*	*Miles.*	*Miles.*	*Miles.*
Pacific slope (Ancon)........	29.85	95	66	79	14	86	92	8.90	75.01	65	39	25.955 NW.	36.755 NW.	59
Central section (Culebra)....	29.86	94	65	78	15	90	94	8.13	94.21	62	33	16.087 NW.	32.873 NW.	36
Atlantic slope (Cristobal)....	29.86	92	66	78	9	84	92	17.94	165.47	75	56	37.019 N...	40.457 SE..	39

FISCAL YEAR ENDED JUNE 30, 1910.

Station.	Annual mean reduced pressure.	Absolute maximum.	Absolute minimum.	Annual mean.	Annual mean daily range.	Humidity dry season.	Humidity wet season.	Rainfall dry season.	Rainfall wet season.	Sunshine dry season.	Sunshine wet season.	Wind dry season.	Wind wet season.	Maximum velocity.
Pacific slope (Ancon)........	29.86	94	63	79	15	86	91	7.19	74.72	50	39	26.323 NW.	37.074 NW.	59
Central section (Culebra)....	29.86	92	61	78	14	87	94	8.95	99.07	40	28	26.850 NW.	32.116 NW.	36
Atlantic section (Cristobal)..	29.87	90	66	78	8	84	91	15.28	166.49	69	54	40.173 N...	42.801 SE..	39

TABLE 8.—*Seismic disturbances recorded at Ancon, Canal Zone, year ending June 30, 1910.*

(Having a maximum amplitude of 10 mm. or more. Latitude, 8° 57′ N.; longitude, 79° 32′ W.)

Bosch-Omori seismographs.

Greenwich mean time. Magnification fifteenfold.

100-K.—NORTH AND SOUTH COMPONENT.

Date.	Preliminary tremors commerce.	Second group commence.	Long waves commence.	Maximum.	End.	Maximum amplitude.	Period of pendulum.
1909.						*Mm.*	*Seconds.*
July 30	10.56 a. m.		11.00 a. m.	11.10 a. m.	12.08 p. m.	14.0	25
Aug. 16	7.00 a. m.		7.02 a. m.	7.03 a. m.	7.39 a. m.	12.0	25
30	1.02 p. m.		1.02 p. m.	1.02 p. m.	(a)	107.0	25
Dec. 1	Absent			1.57 a. m.	1.58 a. m.	10.0	25
1910.							
Jan. 1	(?)		11.09 a. m.	11.12 a. m.	12.33 p. m.	47.0	25
12	2.28 a. m.		2.29 a. m.	2.29 a. m.	2.47 a. m.	37.0	25
23	6.54 p. m.		6.58 p. m.	6.58 p. m.	7.45 p. m.	15.0	25
Apr. 13	6.45 a. m.		6.46 a. m.	6.47 a. m.	7.15 a. m.	15.0	25
28	5.16 a. m.		5.16 a. m.	5.17 a. m.	5.28 a. m.	10.0	25
29			12.53 a. m.	12.53 a. m.	12.54 a. m.	22.0	25
May 5	12.29 a. m.		12.30 a. m.	12.32 a. m.	1.04 a. m.	77.0	25
18				7.33 a. m.	7.33 a. m.	20.0	25
20	12.05 p. m.		12.08 p. m.	12.08 p. m.	12.55 p. m.	29.0	25

100-K.—EAST AND WEST COMPONENT.

Date.	Preliminary tremors commerce.	Second group commence.	Long waves commence.	Maximum.	End.	Maximum amplitude.	Period of pendulum.
1909.							
July 30	10.56 a. m.		11.00 a. m.	11.11 a. m.	12.14 p. m.	17.0	25
Aug. 16	7.00 a. m.	7.02 a. m.	7.02 a. m.	7.03 a. m.	7.39 a. m.	12.0	25
30	1.02 p. m.		1.02 p. m.	1.02 p. m.	(a)	97.0	25
Dec. 1				1.57 a. m.	1.58 a. m.	10.0	25
1910.							
Jan. 1	(?)		11.09 a. m.	11.11 a. m.	12.12 p. m.	70.0	25
12	2.29 a. m.		2.29 a. m.	2.29 a. m.	2.38 a. m.	13.0	25
23	6.54 p. m.		6.58 p. m.	6.58 p. m.	7.30 p. m.	5.0	25
Apr. 13	6.45 a. m.		6.46 a. m.	6.47 a. m.	7.15 a. m.	16.0	25
28	5.16 a. m.		5.16 a. m.	5.17 a. m.	5.26 a. m.	15.0	25
29			12.53 a. m.	12.53 a. m.	12.54 a. m.	18.0	25
May 5	12.29 a. m.		12.30 a. m.	12.32 a. m.	1.04 a. m.	64.0	25
18				7.33 a. m.	7.33 a. m.	10.0	25
20	12.05 p. m.		12.08 p. m.	12.08 p. m.	12.44 p. m.	16.0	25

[a] Record lost.

TABLE 9.—*Seismic disturbances recorded at Ancon, Canal Zone, year ending June 30, 1910.*

(Having a maximum amplitude of 10 mm. or more. Latitude, 8° 57′ N.; longitude, 79° 32′ W.)

Bosch-Omori seismographs.

Greenwich mean time. Magnification fifteenfold.

25-K.—NORTH AND SOUTH COMPONENT.

Date.	Preliminary tremors commence.	Second group commence.	Long waves commence.	Maximum.	End.	Maximum amplitude.	Period of pendulum.
1909.						*Mm.*	*Seconds.*
July 30	10.56 a. m.		11.00 a. m.	11.00 a. m.	11.44 a. m.	12.0	25
Aug. 16	7.00 a. m.		7.02 a. m.	7.04 a. m.	7.44 a. m.	5.0	25
30	1.02 p. m.		1.02 p. m.	1.02 p. m.	1.22 p. m.	42.0	25
Dec. 1				1.57 a. m.	1.58 a. m.	2.0	25
1910.							
Jan. 1	(?)		11.09 a. m.	11.11 a. m.	12.12 p. m.	35.0	25
12	2.29 a. m.		2.29 a. m.	2.29 a. m.	2.40 a. m.	7.0	25
23	6.54 p. m.		6.58 p. m.	6.58 p. m.	7.34 p. m.	4.0	25
Apr. 13	6.45 a. m.		6.46 a. m.	6.47 a. m.	6.16 a. m.	5.0	25
28	5.16 a. m.		5.16 a. m.	5.17 a. m.	5.26 a. m.	4.0	25
29			12.53 a. m.	12.53 a. m.	12.54 a. m.	2.0	25
May 5	12.29 a. m.		12.30 a. m.	12.32 a. m.	1.06 a. m.	32.0	25
18				7.33 a. m.	7.33 a. m.	1.0	25
20	12.05 p. m.		12.08 p. m.	12.08 p. m.	12.42 p. m.	8.0	25

25-K.—EAST AND WEST COMPONENT.

Date.	Preliminary tremors commence.	Second group commence.	Long waves commence.	Maximum.	End.	Maximum amplitude.	Period of pendulum.
1909.							
July 30	10.56 a. m.		11.00 a. m.	11.00 a. m.	11.56 a. m.	6.0	25
Aug. 16	7.01 a. m.		7.03 a. m.	7.04 a. m.	7.45 a. m.	5.0	25
30	1.02 p. m.		1.02 p. m.	1.02 p. m.	1.22 p. m.	39.0	25
Dec. 1				1.57 a. m.	1.58 a. m.	1.0	25
1910.							
Jan. 1	(?)		11.09 a. m.	11.14 a. m.	12.14 p. m.	36.0	25
12	2.29 a. m.		2.29 a. m.	2.29 a. m.	2.40 a. m.	5.0	25
23	6.54 p. m.		6.58 p. m.	6.58 p. m.	7.38 p. m.	3.0	25
Apr. 13	6.45 a. m.		6.46 a. m.	6.47 a. m.	7.11 a. m.	6.0	25
28	5.16 a. m.		5.16 a. m.	5.17 a. m.	5.25 a. m.	4.0	25
29			12.53 a. m.	12.53 a. m.	12.54 a. m.	2.0	25
May 5	12.29 a. m.		12.30 a. m.	12.32 a. m.	1.03 a. m.	27.0	25
18	(a)	(a)	(a)	(a)	(a)	(a)	(a)
20	12.05 p. m.		12.08 p. m.	12.08 p. m.	12.36 p. m.	7.0	25

[a] No record on this instrument.

TABLE 10.—*Table showing extreme high and low water, maximum and minimum range, greatest and least amplitude, and the highest and lowest sea-water temperatures for each month.*

BALBOA TIDES, 1909.

[Elevations are referred to mean sea level.]

Month.	Extreme high and low water and range.						Amplitude.				Temperature of sea water.					
	Elevation.				Greatest range.	Least range.	Greatest.		Least.		Highest.			Lowest.		
	Highest high.	Lowest high.	Highest low.	Lowest low.			Feet.	Day.	Feet.	Day.	° F.	Hour.	Day.	° F.	Hour.	Day.
					Feet.	*Feet.*										
January	9.4	3.2	−3.7	− 9.7	19.1	6.9	18.9	Twenty-fifth	6.9	Sixteenth	82	2 a. m.	First [a]	78	10 a. m.	Eighteenth.
February	10.1	3.4	−3.4	−10.3	20.4	6.8	20.2	Twenty-second	6.8	Fifteenth	82	6 p. m.	Fourth [a]	78	2 a. m.	First.[a]
March	10.2	3.7	−3.2	−10.4	20.6	6.9	20.5	Twenty-third	7.0	Sixteenth	83	2 p. m.	Thirtieth [a]	71	6 p. m.	Tenth.[a]
April	8.6	4.2	−3.1	− 8.0	16.6	7.3	16.6	Eighteenth	7.3	Twenty-seventh	85	6 p. m.	Twenty-fourth	75	6 a. m.	Seventh.[a]
May	9.9	4.2	−2.8	− 8.7	18.6	7.0	18.6	Nineteenth	7.0	Twenty-eighth	87	2 p. m.	Twenty-fourth [a]	78	6 a. m.	Eighth.
June	10.4	4.2	−2.8	− 9.9	20.3	7.0	20.3	Twenty-first	7.2	Thirtieth	86	2 p. m.	Thirteenth	79	Midnight	Twenty-first.
July	8.5	3.8	−3.0	− 7.8	16.3	6.8	16.2	Fifth	6.9	Twenty-eighth	84	4 p. m.	Tenth	79	Midnight	Twentieth.
August	9.8	4.0	−2.4	− 8.4	18.2	6.4	18.1	do	6.4	Twenty-sixth	89	4 p. m.	Twenty-fifth	81	2 a. m.	Fourth.[a]
September	10.7	4.2	−2.3	− 8.9	19.6	6.5	19.5	Thirtieth	6.5	Twenty-fourth	87	4 p. m.	Seventh [a]	82	10 a. m.	Fifteenth.[a]
October	11.2	4.4	−2.7	− 9.4	20.6	7.1	20.6	Second	7.3	Twenty-third	85	6 p. m.	Twenty-fifth	79	Midnight	Fifteenth.
November	9.9	4.2	−2.8	− 9.3	19.2	7.0	19.2	Twenty-eighth	7.2	Seventh	84	4 p. m.	Twenty-ninth [a]	76	Midnight	Seventeenth.
December	9.0	3.6	−3.6	− 8.3	17.3	7.2	17.0	do	7.2	Sixth	82	2 a. m.	First	77	8 a. m.	Twenty-seventh.[a]
Year											89	4 p. m.	Aug. 25	71	6 p. m.	Mar. 10.[a]

[a] Other dates also.

TABLE 11.—*Table showing extreme high and low water, maximum and minimum range, greatest and least amplitude, and the highest and lowest sea-water temperatures for each month.*

CRISTOBAL TIDES, 1909.

[Elevations are referred to mean sea level.]

Month.	Extreme high and low water and range.						Amplitude.				Temperature of sea water.					
	Elevation.				Greatest range.	Least range.	Greatest.		Least.		Highest.			Lowest.		
	Highest high.	Lowest high.	Highest low.	Lowest low.			Feet.	Day.	Feet.	Day.	° F.	Hour.	Day.	° F.	Hour.	Day.
					Feet.	*Feet.*										
January	1.40	0.24	+0.44	−0.50	1.90	0.20	1.68	Twenty-second	0.20	Fourteenth	83	2 p.m.	Twenty-fourth	78	2 a.m.	Twenty-ninth.[a]
February	1.63	.10	+ .35	− .54	2.17	.25	1.59	Third	.20	Nineteenth	83	4 p.m.	Sixth [a]	78	2 a.m.	Second.[a]
March	.95	.0	+ .14	− .59	1.54	.14	1.41	Twenty-seventh.	.21	Sixteenth	85	4 p.m.	Thirtieth	78	8 a.m.	Fifth.
April	1.04	.13	+ .12	− .62	1.66	.01	1.47	Twenty-second	.20	Thirteenth	86	Noon	Twenty-fourth	80	6 a.m.	Sixth.[a]
May	.89	.02	+ .11	− .94	1.83	.09	1.74	do	.21	Twenty-second	85	4 p.m.	Fifteenth [a]	80	8 a.m.	Twentieth.[a]
June	1.17	−.15	+ .07	− .86	2.03	.22	1.67	Nineteenth	.25	Twenty-eighth	85	2 p.m.	Twelfth [a]	80	8 p.m.	Fifteenth.[a]
July	1.18	−.03	+ .15	− .87	2.05	.18	1.76	Fifteenth	.23	Twenty-seventh	85	4 p.m.	Tenth [a]	80	Midnight.	Twentieth.[a]
August	1.22	−.21	+ .26	− .59	1.81	.47	1.51	First	.22	Twenty-ninth	85	2 p.m.	Twenty-eighth [a]	80	2 a.m.	Fifth.[a]
September	1.20	.18	+ .35	− .46	1.66	.18	1.59	Eighth	.21	Tenth	87	2 p.m.	Twenty-first	82	6 a.m.	First.[a]
October	1.42	.13	+ .37	− .60	2.02	.24	1.69	Thirtieth	.20	Seventeenth	85	Noon	Tenth [a]	81	8 p.m.	Fourteenth.
November	1.65	.17	+ .60	− .58	2.23	.43	1.86	do	.21	First	86	4 p.m.	Fourth	75	8 a.m.	Nineteenth.
December	1.25	−.19	+ .41	− .72	1.97	.60	1.97	Twenty-seventh	.22	Tenth	82	2 p.m.	Second [a]	75	2 a.m.	Twenty-eighth.[a]
Year											87	2 p.m.	September 21	75	8 a.m.	November 19.[a]

[a] Other dates also.

HYDROGRAPHY.

STATIONS AND EQUIPMENT.

Gauging stations have been maintained during the year on the Chagres River at Gatun, Bohio, and Alhajuela, on the Gatun River at Monte Lirio, and on the Trinidad River at Lagartera. In addition to these, river-stage stations are in operation at Vigia and Gamboa, primarily for warning stations in flood prediction work. Permanent gauge staffs have been erected during the year on the Chagres River at Frijoles, Tabernilla, San Pablo, and Gorgona, on the Gatun River near the railroad bridge at Monte Lirio, on the Trinidad, Rio Grande, and Caimatillo Rivers, and in the spillway at Gatun.

A meter-rating station is maintained at Bohio, and all meters used at the various stations are tested and rated here at stated intervals and at such other times as seem necessary. A new water-stage register was installed during the year at Gatun to replace an Old French fluviograph previously used at this station which was damaged by the high water in November. Similar gauges also are located on the Chilibre and Pedro Miguel rivers for the purpose of observing data for run-off studies.

GAUGINGS.

On account of the heavy rainfall the discharge of the Chagres River during November and December, 1909, was above the average at all stations, that at Bohio and Alhajuela in November being the largest ever recorded. Besides the work at the regular stations, gaugings have also been made on the Chagres River above Alhajuela, on the Trinidad and Siri Grande above Lagartera, the Obispo Diversion, the Pedro Miguel River, the Rio Grande above its point of entry into the Rio Grande Reservoir, the Caimatillo River at Miraflores, the Cocoli River, and the Chilibre River.

During the dry season in order to avoid tidal influences, the gaugings at Bohio were supplemented by others at Buena Vista about 2 miles above the Bohio fluviograph. About 6 miles above the gauging station at Alhajuela the Chagres River divides into two main branches, and special gaugings have been made to obtain the relative discharges of these streams. The August records showed the following discharge per second:

	Cubic feet.
Pequeni above Dos Bocas	800
Chagres above Dos Bocas	2,120
La Puenta below Dos Bocas	124
Total	3,044

At the same time the discharge at Alhajuela, as taken from the gauge heights and discharge curve, was 3,080 cubic feet per second.

FRESHETS.

Table 16 gives the elevations at the several stations for the river rises, which reached elevation 60 or above at Gamboa.

The first important freshet of the Chagres River occurred on September 14, when the river reached elevation 61.60 at Gamboa.

Flood conditions existed during about half of the month of November, the maximum elevation at Gamboa being 72.60 on November 19, 1909, 9 feet below the flood of December, 1906. This freshet caused the highest water at Gatun, where an elevation of 21.50 was reached. This extreme height was caused by previous rainy conditions which

had caused the water to back up at Gatun, so that there was already high water at that station before the freshet rains of this period. At this time it is estimated that an area of 32.47 square miles was flooded with a volume of 9,652,277,000 cubic feet. At Vigia the observer was obliged to abandon his house and the water-stage register was flooded.

Accurate records were kept, however, by staff readings during the time the automatic register was out of commission. At Gatun the washing away of the construction railway trestles destroyed the automatic register, but river elevations were taken from the staff gauge. About two and one-half times the usual amount of water for the period passed this station during the flood, which, if all had been retained, it is estimated would have raised the elevation of Gatun Lake to about elevation 48.8 above sea level, or about one-third full. (Gatun Lake maximum elevation, 87.) If the total discharge from January 1, 1909, had been impounded Gatun Lake would have been filled by the middle of October and almost half as much more wasted. The maximum height at Lagartera on the Trinidad, which occurred simultaneously with that at Gatun, was elevation 24.05 feet, about 2.5 feet higher than the crest at the latter point, which gave a drop of less than one-fourth foot per mile. This condition resulted in the retention of the run-off above Lagartera, so that the maximum discharge at that station, 4,200 cubic feet per second, occurred sometime subsequent to the maximum height.

Three important freshets occurred during December. The first, which was due almost entirely to rainfall in the Chagres basin above Vigia, was reported from that station on the morning of the 6th, and the river reached almost the same elevations at Vigia and Alhajuela as were reached by the flood of the previous month, but at the other stations on the river the elevations were from 4 to 7 feet lower than those of the previous month.

The greatest flood of the year began on the 26th. The river rose rapidly, and within eight hours after the beginning of the rise at Vigia the observer's house and water-stage register had been washed away. The register at Alhajuela similarly suffered, and telephone communication was interrupted. The crest passed Alhajuela at elevation 121, 2 feet higher than the crest of the flood of December, 1906. At Gatun the elevation of this crest, which passed one and one-half days later, was 19.6, as against elevation 21.5 reached by the November flood. The greatest previous flood of authentic record was that of December, 1906, and the following comparisons are given of the gauge heights and discharges at the several stations:

[Elevations are in feet above mean sea level and discharges in cubic feet per second.]

Station.	December, 1906.[a]		December, 1909.[b]	
	Elevation, crest.	Maximum discharge.	Elevation, crest.	Maximum discharge.
Alhajuela	119.3	92,100	121.0	170,000
Gamboa	81.6	76,066	78.2	[c] 168,000
Bohio	38.6	108,026	38.7	[d] 90,000
Gatun	....	....	19.6	[d] 63,400

[a] From Abbot's Problems of Panama Canal, p. 149.
[b] Gaugings and observations by third division office, chief engineer.
[c] Estimated from Alhajuela discharge and observed conditions at Gamboa.
[d] The comparatively small discharge at these stations is due to regulation of run-off by pondage in Gatun Lake area. This is shown by inspection of the curve on Plate 134.

Before the high water of this flood had subsided, another freshet occurred on the 30th and 31st, the crest of which reached 112 feet at Alhajuela, 32.1 feet at Bohio, and 17.7 feet at Gatun. Much territory was flooded during all of these rises, and during the highest water travel was interfered with on the Panama Railroad, due to submergence of tracks.

Warnings of all rises were sent to officials of the Panama Railroad and the Isthmian Canal Commission from seven to twenty-four hours previous to the arrival of the crest at various points on the river. By this means, property and machinery were safeguarded, and the inhabitants of dwellings in low ground were given time to move to places of safety.

GATUN LAKE.

The closing of the channel of the Chagres at Gatun, the beginning of the formation of Gatun Lake, occurred on April 25, 1910, and on June 30, 1910, the lake at Gatun had reached elevation 14.8. More accurate gaugings of the flow in the Chagres River are now possible, as the discharge is confined to the spillway.

The following diagrams accompany the report of this section:

Plate 131.—Cycle of average monthly discharge, 1890 to 1909, inclusive.
Plate 132.—Mass curves of discharge of Chagres River at Gatun for period of twenty years.
Plate 133.—Curves of discharge duration at Gatun during 1909.
Plate 134.—Fluviograph and mass curves relating to discharge of Chagres River during the flood of December, 1909.
Plate 135.—Curves of discharge duration at Gatun, 1890 to 1909, inclusive.
Plate 136.—Showing two largest freshets of the Chagres at Gamboa—years 1906 and 1909.

The following tables accompanying the report of this section are appended:

Table 12.—Distribution of run-off from portions of Chagres basin.
Table 13.—Mean, maximum, and minimum discharge of the Chagres.
Table 14.—Discharge of the Chagres River at Gatun for a period of twenty years.
Table 15.—Important features of Chagres freshets.
Table 16.—Maximum rates of run-off during freshet periods.

Table 12.—*Distribution of run-off from Chagres basin.*

[Discharges in cubic feet per second.]

Tributary area.	Drainage area.	Mean discharge, calendar year 1909.	Percentage of Gatun flow.	Mean discharge, river year.[a]	Percentage of Gatun flow.	Mean discharge, fiscal year.[a]	Percentage of Gatun flow.
	Square miles.						
Above Alhajuela gauging station	427	5,020	47	5,270	46.5	5,370	45
Between Alhajuela and Bohio gauging stations	352	2,310	22	2,420	21.5	2,590	22
Above Trinidad River gauging station	314	1,600	15	1,730	15.0	1,830	15
Above Gatun River gauging station	127	980	9	1,040	9.0	1,080	9
Between Bohio and Gatun gauging stations and below Trinidad and Gatun River stations.	100	750	7	900	8.0	1,090	9
Total above Gatun gauging station	1,320	10,660	100	11,360	100.0	11,960	100

[a] River year ended April 30, 1910; fiscal year ended June 30, 1910.

TABLE 13.—*Mean, maximum, and minimum discharges, Chagres River, 1909–10.*

Period.	Alhajuela (427 square miles). Discharge in second-feet. Mean.	Alhajuela Maximum.	Alhajuela Minimum.	Alhajuela Per square mile.	Alhajuela Run-off depth on drainage area.	Bohio (779 square miles). Discharge in second-feet. Mean.	Bohio Maximum.	Bohio Minimum.	Bohio Per square mile.	Bohio Run-off depth on drainage area.	Trinidad (314 square miles). Discharge in second-feet. Mean.	Trinidad Maximum.	Trinidad Minimum.	Trinidad Per square mile.	Trinidad Run-off depth on drainage area.	Gatun River (127 square miles). Discharge in second-feet. Mean.	Gatun River Maximum.	Gatun River Minimum.	Gatun River Per square mile.	Gatun River Run-off depth on drainage area.	Gatun (1,320 square miles). Discharge in second-feet. Mean.	Gatun Maximum.	Gatun Minimum.	Gatun Per square mile.	Gatun Run-off depth on drainage area.
1909.					*In.*					*In.*					*In.*					*In.*					*In.*
May	2,420	16,870	960	5.67	6.54	3,220	11,590	1,300	4.13	4.76	780	2,380	285	2.48	2.86	455	3,560	115	3.58	4.13	4,220	13,490	2,260	3.20	3.69
June	4,870	60,200	1,190	11.41	12.73	7,010	26,380	1,680	9.00	10.04	1,870	3,490	440	5.96	6.65	1,170	5,290	185	9.21	10.28	9,880	22,580	2,400	7.48	8.35
July	3,360	16,600	2,210	7.87	9.08	5,630	17,720	2,810	7.22	8.33	1,760	3,110	820	5.60	6.46	850	4,870	370	6.70	7.72	9,920	19,490	5,400	7.52	8.67
August	4,090	21,300	2,300	9.58	11.05	6,600	18,520	3,110	8.47	9.77	2,160	3,480	960	6.88	7.94	780	3,370	485	6.14	7.08	10,980	19,800	6,470	8.32	9.60
September	3,560	32,700	2,280	8.34	9.30	5,550	24,550	2,710	7.12	7.94	1,940	3,500	1,040	6.18	6.90	930	4,350	435	7.32	8.17	9,910	23,000	5,060	7.50	8.37
October	3,660	15,000	2,340	8.57	8.89	8,230	19,400	4,570	10.57	12.18	2,580	3,220	1,620	8.22	9.48	1,160	3,820	550	9.14	10.53	12,590	19,560	8,300	9.54	11.00
November	11,300	82,000	2,300	26.48	29.55	21,380	91,500	4,800	27.44	30.63	2,660	4,200	700	8.47	9.45	2,450	7,500	400	19.29	21.52	28,470	72,800	8,400	21.57	24.04
December	17,300	170,000	3,850	40.52	46.76	19,800	90,000	5,300	25.41	29.33	2,470	4,280	1,480	7.86	9.07	2,600	7,640	740	20.48	23.62	25,800	63,400	8,000	19.55	22.55
1910.																									
January	5,050	34,400	2,200	11.83	13.65	6,160	23,400	2,420	7.91	9.13	1,940	4,090	700	6.18	7.13	805	5,960	340	6.34	7.31	11,740	50,300	4,800	8.90	10.25
February	2,870	31,000	1,700	6.72	7.01	3,080	20,000	1,900	3.95	4.12	840	2,790	715	2.68	2.79	440	5,800	255	3.46	3.60	5,080	23,400	2,600	3.85	4.02
March	1,620	19,400	1,090	3.79	4.37	1,880	12,500	1,220	2.41	2.78	565	2,180	330	1.80	2.08	270	2,360	190	2.13	2.46	3,160	18,000	1,800	2.39	2.76
April	3,140	21,800	1,520	7.36	8.22	3,760	18,000	2,130	4.84	5.38	1,250	2,930	460	3.98	4.44	550	3,480	225	4.33	4.83	4,560	11,650	1,890	3.45	3.85
River year.	5,310	170,000	960	12.44	167.15	7,720	90,000	1,220	9.91	134.39	1,740	4,280	285	5.54	75.25	1,040	7,640	115	8.19	111.25	11,440	72,800	1,800	8.67	117.15
May	5,220	39,000	1,750	12.23	14.12	7,470	19,330	2,450	9.59	11.06	1,880	......	......	5.99	6.91	950	......	......	7.48	8.63	10,270	17,600	4,950	7.70	8.98
June	3,310	27,000	1,850	7.75	8.65	5,950	12,620	3,730	7.64	8.53	1,980	......	......	6.30	7.03	1,140	......	......	8.98	10.02	11,060	14,350	7,060	8.38	9.35
Fiscal year.	5,420	170,000	1,090	12.70	170.65	7,990	90,000	1,220	10.25	139.18	1,830	4,280	330	5.83	79.66	1,080	7,640	190	8.50	115.49	12,050	72,800	1,800	9.13	123.44

Figures opposite names of gauging stations represent total drainage areas above those stations.
Figures for blank spaces not obtainable on account lake conditions.
The 12 months ending April 30 constitute the river year.
The 12 months ending June 30 constitute the fiscal year.
Discharge in cubic feet per second per square mile and run-off depth in inches are compiled from mean discharge.

TABLE 14.—*Discharge at Gatun.*

[In cubic feet per second.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Means.
1890....	6,694	2,518	2,059	2,002	10,624	13,273	13,446	14,190	16,992	16,102	9,842	14,703	10,204
1891....	4,348	2,231	972	972	8,640	5,207	7,781	7,324	7,551	11,099	18,651	12,759	7,295
1892....	3,776	2,059	1,887	3,833	13,731	8,811	18,479	15,162	10,928	14,741	18,022	15,162	10,549
1893....	5,722	3,776	2,346	5,550	7,552	8,009	12,357	17,450	12,416	13,903	18,538	30,037	11,471
1894....	11,442	2,918	1,693	1,259	5,435	6,922	10,070	10,527	12,072	15,162	20,597	20,368	9,872
1895....	7,381	2,231	1,716	1,716	6,750	6,981	7,437	11,214	9,383	11,214	9,842	11,270	7,261
1896....	7,666	2,518	1,430	2,745	8,009	6,809	5,092	5,664	9,612	10,298	12,301	9,783	6,827
1897....	3,318	2,574	1,144	1,430	12,931	6,809	8,296	11,786	11,157	12,129	11,271	11,042	7,824
1898....	9,155	2,746	1,774	3,261	4,348	5,435	10,642	8,583	5,207	8,181	12,701	4,635	6,389
1899....	6,237	2,804	1,602	1,774	3,318	5,092	6,409	9,268	6,866	8,009	8,580	5,835	5,483
1900....	3,433	1,716	1,202	1,144	2,632	4,635	9,096	8,524	7,724	11,329	10,700	6,065	5,683
1901....	2,402	1,602	1,144	915	3,720	4,520	5,148	6,981	9,383	10,242	21,455	7,437	6,246
1902....	18,194	3,376	2,059	3,490	4,318	5,148	4,920	5,492	6,350	9,612	10,814	4,863	6,553
1903....	2,632	1,659	1,030	915	2,461	4,120	6,522	8,868	9,211	9,034	13,503	16,992	6,412
1904....	8,009	3,776	2,289	5,894	4,910	7,652	7,308	5,139	10,792	7,938	12,334	6,681	6,894
1905....	3,140	1,599	1,142	970	4,568	4,283	3,083	6,283	6,395	11,250	7,652	4,624	4,582
1906....	2,164	1,397	988	1,620	3,479	4,321	8,472	10,277	8,824	6,594	12,654	17,237	6,501
1907....	5,399	2,257	1,620	1,090	2,997	5,915	7,135	5,941	8,999	13,479	9,299	5,602	5,811
1908....	1,976	1,046	851	892	5,046	5,025	5,744	8,886	8,708	8,859	14,408	8,017	5,788
1909....	6,505	5,260	2,150	2,215	4,215	9,880	9,920	10,980	9,910	12,590	28,470	25,800	10,658
Means	5,980	2,503	1,555	2,184	5,984	6,442	8,368	9,427	9,424	11,088	14,082	11,945	7,415

NOTE.—From 1890 to May, 1908, discharge estimated from present relations. May, 1908, to January, 1910, from current meter measurements.

TABLE 15.—*Important features of freshets of Chagres since 1906.*

For previous freshets see Annual Report, 1909, page 183.

[Elevations in feet above mean sea level and discharges in cubic feet per second.]

Date (beginning).	Beginning of rise.			Crest of rise.		Duration.		Greatest average discharge for 24 hours.
	Time.	Elevation, water.	Discharge.	Elevation, water.	Discharge.	Beginning to crest.	Beginning to end.	
ALHAJUELA.								
						Hours.	*Hours.*	
Dec. 2, 1906..........	2 p. m.	94.4	2,720	118.9	92,100	21	58	59,400
Nov. 16, 1909..........	9 p. m.	94.4	4,400	111.4	82,000	58	105	66,840
Dec. 26, 1909..........	6 a. m.	96.2	9,400	121.0	170,000	13	54	95,700
GAMBOA.								
Nov. 16, 1909..........	9 p. m.	49.8	....	72.6	....	64	138	....
Dec. 26, 1909..........	7 a. m.	51.6	....	78.2	....	16	76	....
BOHIO.								
Dec. 2, 1906..........	9 p. m.	8.9	6,530	38.6	108,030	34	135	90,340
Nov. 16, 1909..........	10 p. m.	12.7	10,000	37.2	81,500	98	(a)	75,100
Dec. 26, 1909..........	9 a. m.	13.5	12,000	38.7	90,000	27	(a)	78,400
GATUN.								
Nov. 17, 1909..........	1 a. m.	8.3	19,400	19.8	72,800	110	(a)	71,200
Dec. 26, 1909..........	5 a. m.	4.7	12,600	17.85	63,400	50	(a)	61,500

[a] Following freshets merged with these before river had reached normal stage.

TABLE 16.—*Maximum rates of run-off during freshet periods for floods exceeding elevation 60 at Gamboa, year ending June 30, 1910.*

CHAGRES RIVER DRAINAGE BASIN.

[Height in feet above mean sea level. Discharge in cubic feet per second.]

Date.	Alhajuela.				Gamboa.			Bohio.					Gatun.					Drainage basin.	
	Time.	Height.	Momentary rate of discharge.	Twenty-four-hour rate of discharge.	Date.	Time.	Height.	Date.	Time.	Height.	Momentary rate of discharge.	Twenty-four-hour rate of discharge.	Date.	Time.	Height.	Momentary rate of discharge.	Twenty-four-hour rate of discharge.	Momentary rate of discharge.	Twenty-four-hour rate of discharge.
1909.					1909.			1909.					1909.						
Sept. 14	3 a. m.	103.15	32,700	13,800	Sept. 14.	8 a. m.	61.60	Sept. 14.	4 p. m.	20.45	24,350	18,800	Sept. 15.	9 a. m.	9.85	23,000	22,600	72,400	48,000
Nov. 12	5 a. m.	102.10	27,200	16,100	Nov. 12.	1 p. m.	64.00	Nov. 13.	1 a. m.	26.70	40,700	29,270	Nov. 13.	11 a. m.	13.50	36,000	35,300	100,000	65,100
19	6 a. m.	111.40	82,000	66,840	19.	11 a. m.	72.60	20.	6 a. m.	37.20	81,500	75,100	20.	3 p. m.	19.85	72,800	71,200	120,000	87,500
Dec. 11	10 a. m.	110.60	85,000	59,030	Dec. 11.	5 p. m.	67.90	Dec. 12.	3 a. m.	30.80	55,000	47,630	Dec. 13.	11 a. m.	15.95	51,800	47,600	80,000	71,200
26	7 p. m.	121.00	170,000	95,700	26.	11 p. m.	78.20	27.	11 a. m.	38.70	90,000	78,400	28.	9 a. m.	17.85	63,400	61,500	124,000	94,000
30	11 a. m.	112.00	97,200	43,500	30.	4 p. m.	69.50	31.	2 a. m.	32.10	58,500	38,600	31.	9 a. m.	16.10	52,600	51,200	60,000	57,000
1910.					1910.			1910.					1910.						
May 28	7 p. m.	104.00	39,000	14,400	May 29.	1 a. m.	61.90	May 29.	7 a. m.	23.50	30,000	20,000	May 29.	3 p. m.	18.88	17,600	17,000	57,600	34,000

GENERAL SURVEYS.

The principal work of this section has been the completion of the survey of the watershed of the Chagres River, a survey of the watershed of the Rio Grande reservoir above high-water mark (elevation 238), the triangulation survey of the Canal Zone, and the care of the precise level bench marks and Zone boundary monuments.

CHAGRES RIVER SURVEY.

The field work in connection with this survey was completed in September. The notes have been worked up and the information obtained has been used in the preparation of a general map of the Isthmus on a scale of 1 : 100,000.

RIO GRANDE WATERSHED.

A survey of this watershed was made in connection with a project to increase the water supply from this reservoir. Close topography was taken up to the 260-foot contour, more open work above, and a contour map was made of the entire basin. The field work in connection with this survey was completed in October.

PRECISE LEVEL BENCH MARKS.

Owing to construction work at different points, it has been necessary to remove a number of these bench marks. New stations, similar in construction to the old ones, have been erected and precautions taken to get accurate results.

The entire line of precise levels was gone over in November, the immediate location of the bench marks cleared of brush and grass, and the pipes and fences given a coat of white paint in order to easily identify them hereafter.

ZONE BOUNDARY MARKS.

The care and maintenance of the monuments marking the Canal Zone boundary was, by the provisions of the chairman's circular No. 332, placed in charge of this division and the necessary attention given to this work.

TRIANGULATION SURVEY.

This survey has been under way during the greater part of the year. The field work has been greatly interfered with by weather and climatic conditions. Considerable difficulty has been experienced also in making connection for the triangles on the northeast side of the Zone on account of dense forests, untraveled and uninhabited country, and the fact that the ridges are all of about the same relative elevation. These difficulties have been overcome and a system of triangles laid out and observations nearly completed which promise excellent results.

In entering upon this undertaking it was found that all existing base surveys had been made independently, and that very little, if any, work had been done toward checking and combining with each other. The first work, therefore, was a complete readjustment of these surveys, in order to properly use the data and tie them into the main system.

Nineteen new stations have been established, which, with the three United States Coast and Geodetic stations near Colon wireless, Colon light, and Toro Point light, will comprise the triangulation net covering the entire Zone from the Atlantic to the Pacific oceans. Observations had been completed at seven of these stations on June 30, 1910, and good progress has been made at the remaining points. The location of the stations relative to each other and to the Canal Zone is shown on the accompanying map. (Pl. 137.)

The intention in carrying on this work has been to have it of such reasonable accuracy that all previous surveys, including construction work and canal lines, could be hung thereto and form a complete system. The land survey of the entire Zone was also kept in mind with the intention of expanding from this triangulation, which would form a base for this and for all future surveys. Two 7-inch theodolites have been usually employed, and the angular work has been performed under the following directions:

For the angular measurements:

Both verniers to be read on the first and sixth readings of each set.

A "set" is a measurement of the angle and a measurement of the explement of the angle, in clockwise direction, with six repetitions of the angle itself and six repetitions of the explement.

In each set the angle will be measured with the telescope in reversed position, and the measurement of the explement must follow immediately the measurement of the angle.

Six complete sets will be made on each angle, and these will be uniformly distributed over the circle, the initial reading being increased each time by an amount equal to $\frac{360°}{mn}$, where m equals number of sets to be taken and n equals number of verniers.

In order to distribute the readings over different parts of the vernier, the index of the vernier is also to be put ahead for each set an amount equal to $\frac{1}{m}$ part of the smallest division of the circle.

A principal base line nearly $2\frac{1}{4}$ miles in length has been laid out over the dumps at Tabernilla, and it is expected to lay out another of a little less length across the dumps at Balboa. The United States Coast and Geodetic Survey had established a base line about three-fourths of a mile long near Cristobal in 1905. From examination of the map (Pl. 137) it will be seen that the Tabernilla base is approximately about half way between the other two mentioned above. This has been cleared and laid out and is nearly ready for measurement. This work will be done under the following directions:

Base lines will be measured with 150-foot Invar tapes and proper tension apparatus. A signal flag is to be erected at each end of the base line, and it shall be cleared, fully staked out, and its grade determined instrumentally.

The base shall be measured in sections approximately 3,000 feet in length, except that one shorter section may be used.

The measurement shall be done with four Invar tapes. A fifth tape shall be carefully kept and used only as a comparator, and a sixth shall be retained for use only in case of damage to one of the four working tapes. Each section shall be measured with two different tapes, each used in an opposite direction. Different pairs of tapes shall be used on different sections, so that the four tapes used on the base shall be thoroughly intercompared. Two, and only two, measurements of each section shall be made, unless the discrepancy between these two measurements exceeds 20 mm. $\sqrt{K}$ (K being the length of any section in kilometers), in which case additional measurements must be made until two are obtained which agree within this limit. All the tapes used in these measurements shall be compared before and after

use with the comparator and shall be standardized before and directly after use by the Bureau of Standards, at Washington.

The tension to be applied to the tapes during measurements will be 15 kilograms (about 33 pounds). The balances used on the measures shall be tested in a horizontal position between the measurement of each section with a 15-kilogram weight hung on the hook of the balance by a small cord passing over a pulley. Temperatures also must be noted.

The base line will be laid out as follows, using the 7-inch theodolite and a Wye level which is in correct adjustment: 4 by 6 inch posts are to be driven every 150 feet along the line; 2 by 4 inch stakes are to be driven 75 feet apart between the posts, and a nail driven horizontally into each to support the tapes, each nail being in a straight line between the tops of the adjoining posts. The edges of these stakes are to be set accurately on the base line, and a line marked on top of the posts, using a theodolite for this purpose. Short sights must be taken, and only a forward line run in order that errors of alignment may be obviated as far as possible. Wherever the posts can not be driven until solid, they are to be braced rigid.

The elevations of the tops of each post and of all intermediate stations will be obtained from a double line of levels. These levels will be connected with the nearest "precise level" bench mark, using the bolt in the tile and not the top of the cap. Two special pipe wrenches will be necessary to remove the cap. The whole base will be reduced to sea level, each section being computed separately, using the formula $C=s\frac{h}{r}$, where C is the reduction to sea level for the section length s and mean height h, r being the radius of curvature of the earth for latitude 9° 8′. Log. r in feet=7.3207198. The horizontal length of the base line shall be computed from the data obtained by running the levels over the base-line posts.

SURVEY OF ZONE LANDS.

Included in the sundry civil act passed by the last Congress was an item covering the expense of a survey of the Zone lands, and preparations have been made to take up this work under the following directions:

Item 1.—For purpose of future allotment and subdivision, the land area of the Canal Zone shall be laid off into quadrilaterals. The bounding sides of these quadrilaterals shall be 2 kilometers (1.243 statue miles), as near as may be, and the area shall be 4 square kilometers, equivalent to 400 hectares, and approximately 988.42 acres. The maximum allotment shall be equivalent to one-eighth of the area of a quadrilateral, equal to 50 hectares, and approximately to 123.552 acres. Act of Congress approved February 27, 1909.

Item 2.—The lotting up or subdivision of the Canal Zone lands shall be referred to a system of rectangular coordinates.

Item 3.—The "initial point" or "origin" of this system shall be the primary triangulation station on Balboa Hill.

Item 4.—The axes of coordinates through the initial point shall be—

(*a*) A north and south line to be known as the "standard meridian," which will be the true meridian passing through the initial point, its location being determined by the primary triangulation system.

(*b*) An east and west line to be known as the "standard base line," which passing through the "initial point" is laid off geometrically at right angles or 90° from the "standard meridian."

Item 5.—The north and south boundary lines of the quadrilaterals shall be laid off as near as may be parallel with the standard base line and the east and west boundary lines shall be laid off as near as may be parallel with the "standard meridian."

Item 6.—Certain of the boundary lines above referred to and at distances apart not greater than 10 kilometers (6.21 statute miles, approximately) in a north and south or east and west direction, shall be run with the utmost care, all stakes and hubs being firmly set, the tops of the same being accurately leveled over, and standardized tapes and tension apparatus used to determine distances. In measuring distances, either base line clinometers will be used or the tapes will be held directly on the top of the stakes and hubs. In all cases, the correct horizontal distances will be calculated from the relative elevations of the ends of the tape and the initial measured distances. Under no circumstances will plumbed horizontal lines be used in the work set forth in this item. These lines will be known as "standard guide lines, N., S., E., or W," as the case may be, when referred to the "standard base line" and the "standard meridian."

Item 7.—The remaining boundary lines of the quadrilaterals shall be run with a less degree of precision, but before permanently marking the corners these boundary lines shall be carefully adjusted with reference to the "standard guide lines," bounding the total area under consideration.

Item 8.—At the intersection of the "standard guide lines" permanent monuments of concrete and iron shall be erected. These monuments will be called "guide monuments" and their location shall be referred—

(*a*) To a system of rectangular coordinates referred to the axes of coordinates mentioned in item 2, et seq.

(*b*) To their geodetic position on the surface of the globe which shall be obtained by reference to the primary system of triangulation.

These monuments shall consist of a section of standard railroad rail about 4 feet long, at least 2½ feet of which shall be below the surface of the ground and solidly embedded in concrete. The rail shall project 1½ feet above the ground and shall be surrounded with concrete. This monument shall be similar to a standard monument, a drawing of which will be hereafter submitted for approval. The top of the rail shall be flush with the surface of the concrete, and so located that after the monument has been completed a deep cross can be cut thereon, the lines of which will cross the point of intersection of the "standard guide lines."

Item 9.—Except as above designated, all intersecting corners of the quadrilaterals shall be marked with a section of wrought-iron pipe 3½ inches in diameter and not less than 4½ feet long, which shall project 1½ feet above the surface of the ground. The bottom of this pipe shall be split for a distance of 6 inches at three places in the circumference and splayed. The tops shall be closed with a composition cap with lettering and marks to be hereafter approved. The center of this cap shall be placed as near as may be at the intersection of the boundary lines.

Item 10.—Whenever the words "primary triangulation" are referred to in these specifications, they shall be construed to mean the triangulation survey made in 1909–10, under the direction of the third division of the office of the chairman and chief engineer.

Item 11.—During the progress of this survey topography of suitable detail shall be taken to indicate the location of all trails, roads, property lines, hills, streams, and villages crossed by the boundary lines of the quadrilaterals. Included in this survey sufficient work shall be done to locate with a fair degree of accuracy all watersheds tributary to the Zone limits, and all streams entering the Zone are to be traced to their headwaters, unless otherwise directed. Sufficient topography shall be taken on the survey lines to draw contours crossing these lines at 10-foot intervals, and such additional work shall be done as will enable the interior topography of the quadrilaterals to be determined with some degree of accuracy.

Item 12.—For the purpose of facilitating reference and utilizing this survey hereafter the data obtained shall be placed on the following plans and maps:

(*a*) Large-scale *record* plans, outside dimension 56 by 48 inches, scale of drawing 1 : 2,000, or approximately 1 inch equals 167 feet. Each of these plans would cover 4 square kilometers of territory, would be used as a record plan of the allotments in that quadrilateral, and would contain all information regarding the location in detail. To cover the entire Zone, land and water, would require 363 of these sheets, and they could be conveniently bound in folios of 25 or 50 each.

(*b*) Medium-scale *district* plans, scale 1 : 20,000, or approximately 1 inch equals one-third mile. These plans would cover the entire Zone, their boundaries being limited by the drainage basin of the principal streams. They would show the general lay of the land, its topography, and availability for general development. The principal use of these plans would be in the comprehensive layout of roads and trails, the interrelation of villages and plantations; the character of the country and its adaptability for special uses of agriculture, grazing, or plantation work of various kinds. Such plans will be exceedingly valuable for various purposes of municipal work and in matters of sanitation and policing.

(*c*) Small-scale *general* map of the entire Zone, including the lake, scale 1 : 40,000, approximately five-eighths inch per mile. This to be the general map of the entire territory and to contain some information of the territory immediately contiguous on either side of the Zone boundary lines. On this map would be sketched an outline of the work set forth on the two series mentioned above, making available a map on a fairly large scale made up from actual surveys. All existing surveys of record would be used in the compilation of this map.

The following map accompanies the report of this section:

Plate 137.—Map of triangulation system showing stage of completion July 1, 1910.

EXPLORATIONS.

The principal work of this section has been the exploration for low places on the westerly borders of the proposed Gatun Lake. The kind and extent of the materials underlying these saddles were determined by diamond drilling and by topographical and geological surveys. Special and exhaustive tests for the stability and permeability of the materials have been made. The investigation of the Escoval saddles had been completed and was reported at length in the report for fiscal year 1909.

The work during the past year has been in the following locations:

ARROYA.

The Arroya saddles, six in number, are about 12 miles southwest of Gatun in approximate latitude 9° 07′ 30″ and longitude 80° 1′, with elevations, respectively, of 113.5, 112.7, 116.4, 111, 109, and 111.8 feet above mean sea level, all within a distance of 1½ miles. The thinnest place through the ridge at elevation 85 is 500 feet, of which 400 feet is rock. The materials found were clay, decomposed rock, argillaceous sandstone, sandstone, and conglomerate. But little water was lost while drilling, and the two places where this occurred were above elevation 85. The ground water in all the holes also stood above this elevation. The work here seems to show (1) that there will be very little, if any, seepage through the ridge; (2) that the ridge is of much greater thickness than is necessary to restrain the waters of the lake; and (3) that the materials exposed to the action of the waters in the lake would be little affected by erosion.

CANO.

The Cano saddles are about 14 miles southwest of Gatun in approximate latitude 9° 6′ 30″ and longitude 80° 3′. There are six low places in the ridge, all within a distance of 1½ miles, with elevations respectively of 115.2, 115, 105.2, 87.4, 94.9, and 98.4 feet above mean sea level. With the exception of saddle No. 4 (elevation 87.4), the thinnest place in the ridge at elevation 85 is 250 feet through, but the imperviousness of the materials, the flatness of the slope on the ocean side, and the fact that there is now at elevation 68 on the Atlantic side a large swamp in which water stands throughout the year is thought to indicate that no appreciable seepage from the lake is likely to occur. Saddle No. 4 is a long narrow ridge 800 feet in extent between the 90-foot contours and 1,200 feet between the 110-foot contours. At elevation 85 in the lowest part of this saddle the distance through the ridge is but 50 feet, and at no place between the 90-foot contours is it more than 100 feet. While drilling at this point, water was lost at a depth of 15.5 feet below the surface. It probably will be necessary to reinforce this saddle and increase its height, which is a simple matter, considering the imperviousness of the materials of which it is composed and the fact that the deepest excavation necessary to reach rock is about 25 feet.

LAGARTO.

The Lagarto saddles are the most southerly of the low places on the westerly side of Gatun Lake, and are about 15 miles southwest of

Gatun in approximate latitude 9° 5′ 30″, longitude 80° 3′ 30″. The ridge rises rapidly from this place to the high lands at the headwaters of the Siri River. There are three low places within a distance of 3,500 feet, with elevations, respectively, of 106.1, 106, and 119.3 feet above mean sea level. The materials found here are similar to those underlying the Arroya and Cano saddles, but more impervious, no water being lost while drilling. The thinnest place in these saddles at elevation 85 is 450 feet through, of which 350 feet is argillaceous sandstone, and at no place on the axis of the divide does the rock line fall below elevation 95. Considering the character of the materials underlying the saddles, their thickness at elevation 85, the flatness of the slopes on the Atlantic side, and the elevation of the ground water, it seems that they are perfectly safe without any reinforcement.

GATUN WEST.

On account of the low elevation of the ground water found during the investigation of the dam foundation in 1907–8 in the ridge which will form a part of the west end of the Gatun dam, it was deemed advisable to further investigate this ridge during the past year. A special report was submitted on this location under date of February 26, 1910.

Eight holes, with surface elevations of +31.6, +78, +17.2, +92.5, +61.3, +124.5, +82, and +97.3 were drilled to the following depths, respectively, −10.2, −4, −27.8, −12.5, −21.7, −0.5, −1.7, and −4.4. The materials found were clay, decomposed rock, and argillaceous sandstone, the average depth to rock being about 10 feet.

No unfavorable conditions were found except at hole 2006 (surface elevation, +124.5), where water was lost at elevation +29 and at several lower elevations to the bottom of the hole at elevation −0.5. Extensive tests showed that about 60 per cent of the water discharged into hole 2006 appeared again about 700 feet away in a small stream near hole 2005 on the lake side of the ridge. In order to guard against possible danger from this condition, the precaution has been taken to shift the axis of the dam upstream at this point and install cut-off trenches.

GATUN EAST.

These saddles are located about ½ mile east of Gatun in latitude 9° 16′ 30″, longitude 79° 55′. Three low places with elevations, respectively, of 97.8, 85.7, and 110.3 were investigated. The materials found were clay, decomposed rock, volcanic tufa, conglomerate, and argillaceous sandstone, the rock being found near the surface. These materials were found to be very impervious with the exception of a stratum of conglomerate in the lowest saddle (elevation 85.7) Here, in hole 2010, water was lost at elevation 51.7 at the rate of about 1 cubic foot per minute. This conglomerate was also found near the surface (elevation 74) in hole 2009 on the lake side of the saddle and in hole 2011 on the Atlantic slope at elevation 32.5. Extensive tests showed very little if any connection between the ground water in the various levels. While there would probably be very little seepage under full lake conditions, this saddle, on account

of its low elevation, requires reinforcement, which could satisfactorily be accomplished by a dam across the ravine at hole 2009, the distance being only about 350 feet.

QUEBRANCHA.

These saddles, located about 10 miles northeast of Gatun in approximate latitude 9° 20′ 30″, longitude 79° 48′ 30″, are now being investigated. Four low places, with elevations, respectively, of 121.3, 136.8, 142.5, and 138.5, have been found. The ridge is narrow, with exceedingly steep slopes until elevation 80 is reached. The materials found have been clay, sand, gravel, sandstone, and conglomerate, but thus far no unfavorable conditions have been encountered.

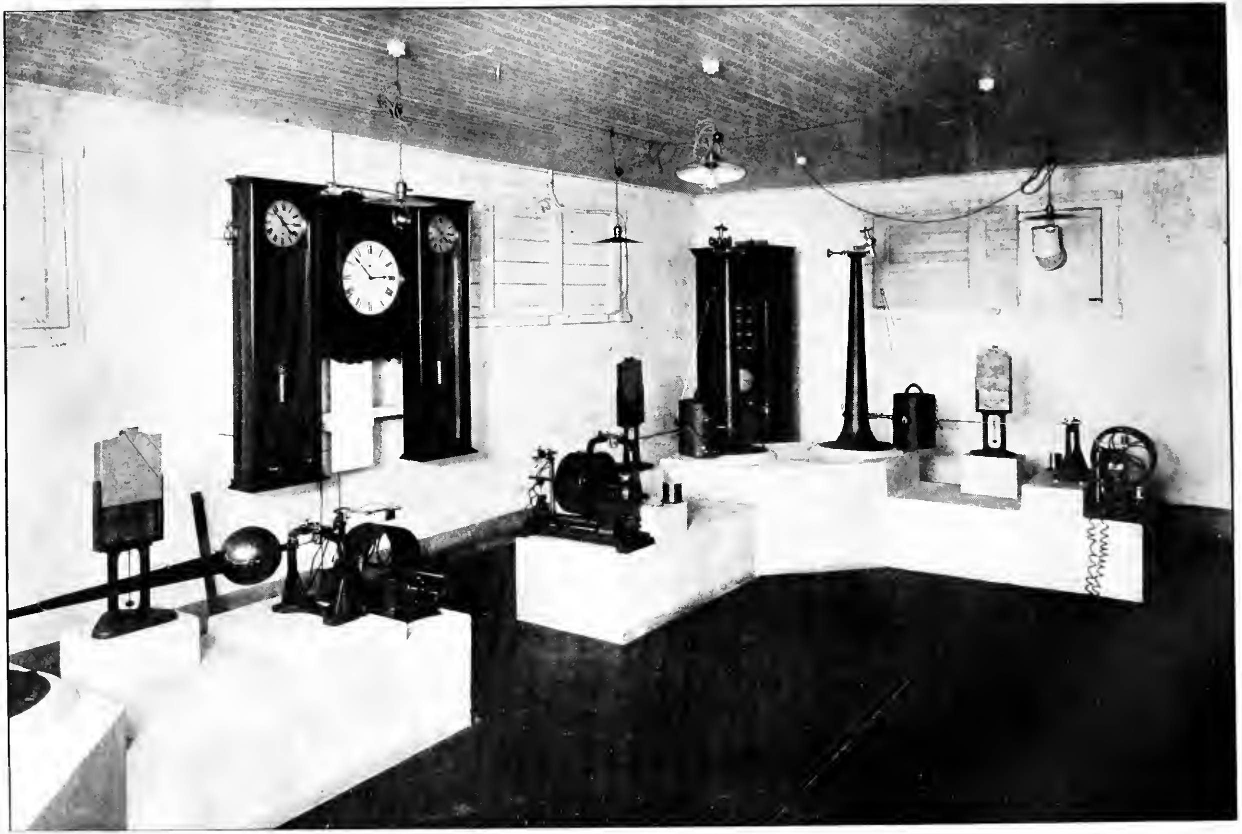
SPECIAL INVESTIGATIONS.

The work of this section has included the reviewing and commenting upon such matters as have been assigned by the chief engineer for special study.

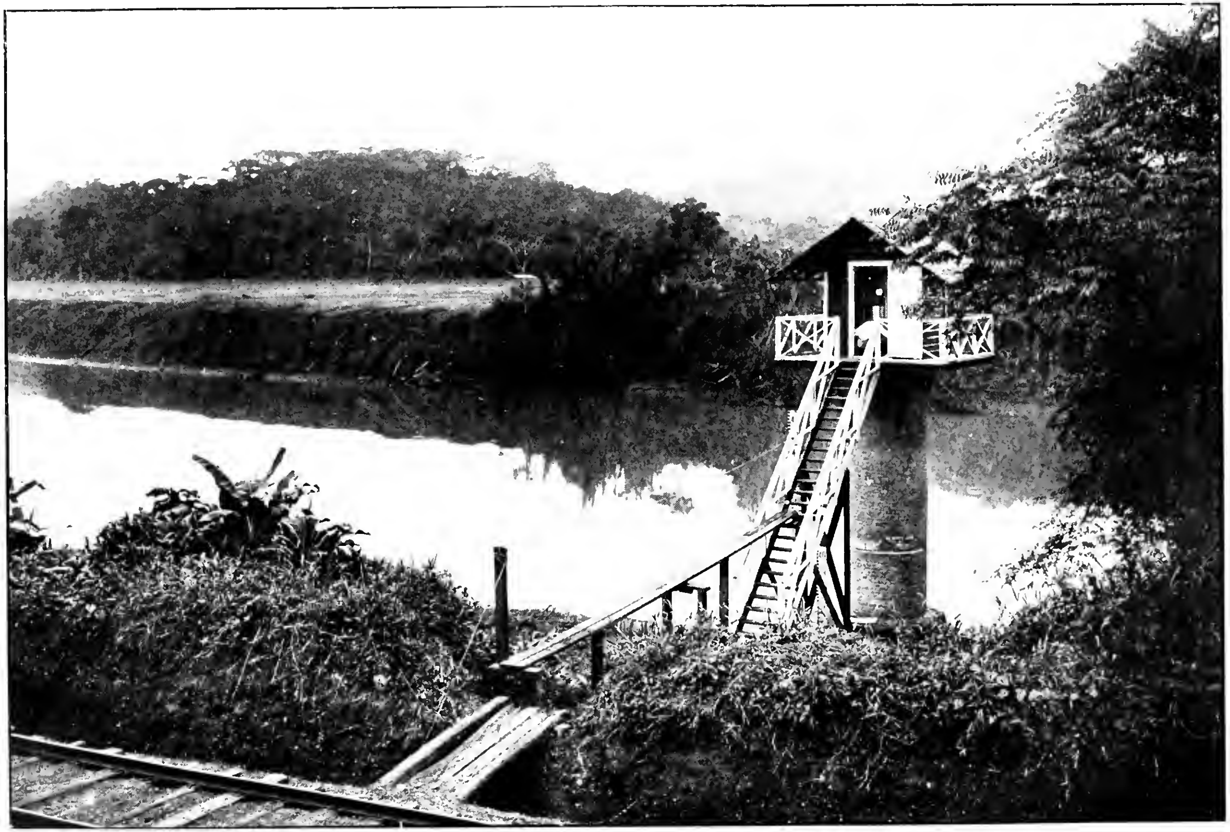
Respectfully submitted.

C. M. Saville,
Assistant Engineer.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.



INTERIOR OF SEISMOGRAPH ROOM, ANCON OBSERVATORY, 1910.



FLUVIOGRAPH STATION ON CHAGRES RIVER AT BOHIO, 1910.

TRIANGULATION STATION ON TOP OF ANCON HILL, AUGUST, 1910.

APPENDIX K.

REPORT OF LIEUT. COL. C. A. DEVOL, QUARTERMASTER'S DEPARTMENT, U. S. ARMY, CHIEF QUARTERMASTER, IN CHARGE OF QUARTERMASTER'S DEPARTMENT.

Isthmian Canal Commission,
Quartermaster's Department,
Culebra, Canal Zone, July 1, 1910.

Sir: I have the honor to submit the following report of the operations of the quartermaster's department for the fiscal year ending June 30, 1910.

Changes in the organization of the department during the year were as follows:

First. Transfer of dock No. 14, Cristobal, from the Panama Railroad Company to the quartermaster's department, effective December 1, 1909.

Second. Transfer of the storehouses at Balboa and Miraflores from the Pacific division, and of those at Gatun, Cristobal dry dock, and Porto Bello from the Atlantic division, to the quartermaster's department, effective January 1, 1910.

Third. Consolidation of the Bas Obispo and Las Cascadas districts, effective July 1, 1910.

Fourth. Elimination of the gardens and the transfer of the horticultural work to the district quartermasters.

Fifth. Transfer of the requisitions for skilled labor to the office of the chairman and chief engineer.

PERSONNEL.

On June 30 the effective force at work in the quartermaster's department was 3,326 men, 232 of these being on the "gold" roll and 3,094 on the "silver" roll.

For the month of June, 1908, the pay rolls of the department of labor, quarters, and subsistence and of the division of material and supplies amounted to $151,500.14. For the month of June, 1910, the pay roll of the quartermaster's department was $131,122.39. To make the comparison exact, eliminating the subsistence and personnel from the first pay roll and the building and sanitary work from the second there results, for performing the same class of work, a total of $120,138.12 for June, 1908, as against $89,484.50 for June, 1910.

Taking up the various fields of work of the department in sequence:

LABOR.

Few laborers were recruited during the year. There were but three shipments, aggregating 2,519 men. All were West Indians—two shipments from Barbados and one from Trinidad. The last shipment was made in January, 1910.

The excess of immigration over emigration during the year was 21,114. The work has apparently reached its maximum, and the present population of the Zone with its constant accessions furnishes an ample labor supply. Although it has been necessary to import 43,000 laborers since the inception of the work, it is now believed that the recruitment of unskilled labor can be abandoned.

While there has always been an independent immigration from the West Indian Islands, it was not until within the last four months that there has been any movement on the part of European laborers. During this period 2,000 have come here of their own volition, unassisted, attracted by the reports of good pay, fair treatment, and excellent living conditions sent to Spain and Italy by laborers on the ground.

A number of old contract laborers who had deserted the work have returned, as evidenced by the fact that although no Europeans have been recruited during the year a number of them have paid up their transportation in full, amounting to $3,700. This is in striking contrast to the previous fiscal year, when at one time it seemed as though the force would be seriously depleted by the movement of the Spanish and Italian laborers who were going to Brazil and other South American countries. A number of these men have returned.

The main office of this department acts as an employment agency, keeping in touch with the labor requirements of the work and placing new arrivals where they are most needed. Spanish and Italian laborers, noncontract, are paid at the rate of 16 cents "gold" per hour.

From the beginning of the fiscal year until April there was a steady increase in the force; the maximum, 38,676, was reached on March 30, 1910. This includes the force of the Panama Railroad Company and of the relocation, and is the largest force on record. It is 5,000 over and above the maximum figure of the previous fiscal year. Since that time there has been a decrease, but the total effective strength on June 30 was still 35,578, as compared with 33,493 shown by the report of June 30, 1909.

QUARTERS.

GOLD.

The situation is satisfactory. Nineteen new houses for married employees, accommodating 38 families, were completed during the year. Eleven buildings, accommodating 29 families, were converted into "gold" married quarters. The bulk of the new construction was at Ancon and Gatun.

The No. 1 list has been practically eliminated, which means that the Isthmian Canal Commission has furnished married quarters to all applicants who were employed prior to January 1, 1908. There are 525 applications for married quarters on the No. 2 list, half of them being at Gatun and Cristobal. Of these applicants, 84 are occupying nonhousekeeping quarters, and of the total of 1,686 families who occupy quarters 656 were assigned from the No. 2 list.

The expansion of the work at Gatun created a demand for additional bachelor quarters, and four type 18 houses, accommodating 192 bachelors, were erected at that point. There is no congestion in bachelor quarters at the present time.

As far as possible, the department has pursued the policy of utilizing every building on the Isthmus. As the progress of the work has caused the number of employees at points like Culebra, Empire, and Paraiso to decrease, the vacant bachelor quarters have been utilized for what is termed "nonhousekeeping quarters," for the use of employees working at points where they are unable to secure family quarters. Suites of two or three rooms are assigned to each family. No stoves are furnished, but cooking is permitted. While the accommodations are not equal to those in the regular married quarters they afford men on the No. 2 list, who would not otherwise stand a chance, an opportunity of having their families near them.

SILVER.

The number of negroes in quarters remains practically the same, viz., 4,925 bachelors, and 1,067 families. There seems to have been no movement to the bush during the past year.

There has been an increase of 1,300 in Europeans occupying commission quarters. "Silver" quarters are plentiful, except at Porto Bello, where one barrack has been constructed and another authorized.

The labor camps at Ancon, Cartagenita, Cucaracha, Santa Cruz, and Mamei have been abandoned, and those at Juan Grande, Chagrecito, Coca Lane, and Sin La Voy have been demolished or sold. The last four were all in the lake area.

GENERAL REMARKS.

Equitable rules cover the assignment of quarters and the allowance of furniture. These rules are being administered by a body of district quartermasters who have now received such training in their work that they are handling it in a most satisfactory manner. It is believed that the problems pertaining to this branch of the work have been solved.

SANITATION.

The work performed for the sanitary department has increased. The increase of population along the Zone has increased the amount of garbage to be removed. A new incinerator has been installed at Empire, and incinerators put in at Pedro Miguel and Miraflores. In spite of the added work, total costs are less for this part of the work.

The sanitary department's request for grass cutting cover a largely increased acreage, and at the beginning of the present rainy season larger gangs were found necessary to accomplish the work.

CORRALS.

A new corral at Ancon was completed during the year. It is the largest on the Isthmus, is of a permanent nature, and can be used after the completion of the canal work.

Economies were effected in delivery service. More animals have been available for and more have been used in construction work than at any other period on the canal work. Teams were used in the spillways at Miraflores and Gatun, on the reservoirs at Gatun and Toro Point, in the canal bottom at San Pablo, and on paving and sewer work in the city of Panama.

There has been an unusually heavy loss of mules during the year. A number of the older animals, purchased during 1904 and 1905, have died, or have been condemned and sold. There was an outbreak during the year at the Ancon and Gatun corrals of an infectious disease called swamp fever. It is a trypanosoma disease, analogous to the surra of the Philippine Islands; is highly infectious, and is considered incurable. Twenty-two animals died of this disease, and it was only through prompt action and most constant care that it was confined to so few animals.

BUILDING AND CONSTRUCTION.

There are 3,078 buildings in the Canal Zone owned by the Isthmian Canal Commission, 1,931 of them having been built by the commission and 1,147 by the French. All repair work pertaining to these buildings and all new construction was placed under this department at the beginning of the present fiscal year. Prior to that time only minor repairs had been handled by this department.

Lieut. W. D. Smith was appointed constructing quartermaster June 24, 1909, and organized this branch of the work.

When the work was turned over the supervisory force consisted of an architect, a chief draftsman, 4 draftsmen, 1 general foreman, and 1 levelman; monthly pay roll of $1,525. The present force consists of the constructing quartermaster and 1 assistant; monthly pay roll of $508.

The allotment for new construction and repairs for the fiscal year was $625,000, of which $478,000 was expended.

Ninety buildings were completed during the year. They covered every class of construction—Young Men's Christian Association clubhouse, hospital wards, corrals, engine houses, storehouse, fire station, markets, schoolhouses, and quarters. Fifty of these 90 were built by contract, the contractor performing the labor and the commission furnishing material. In no case has the contractor been handicapped by lack of material. The greater part of the new construction was at Ancon, Gatun, Cristobal, and Toro Point.

All new buildings show a reduction in the unit cost. A comparison with the report made up under the direction of the assistant to the chief engineer, which gave the average cost of all buildings up to August 30, 1908, shows that the buildings constructed during the fiscal year show a reduction of 30 per cent in the cost of type 14 houses, 30 per cent in the cost of type 17 houses, and 33 per cent in the cost of type 18 houses, the three most common types used for quarters.

The average cost of the four Young Men's Christian Association clubhouses first constructed was $31,170; of the Young Men's Christian Association constructed at Gatun, $21,312.

The buildings at Toro Point were authorized on April 18. The force of the constructing quartermaster began operations on May 12, and the force of the contractor on May 23. On July 1 the hotel, laborers' mess hall, one type 18, and three barracks were completed, and all American employees and most of the laborers were quartered and fed in the completed buildings. At no other point on the Isthmus has such rapid construction been effected, with results so good, to wit, that within less than three months after the inception of the work the force has been comfortably sheltered and fed.

Eleven buildings were converted into married quarters, 57 sold, 108 demolished, and 27 moved. Of the 27 moved, 10 were moved to sites in the same district and 17 taken down in sections and moved to other districts. The majority of the buildings sold and demolished were in the lake area, and it is the policy of the department to dispose, as soon as possible, of all the buildings in this section, which are not now being used.

The cost of repairs to buildings has been as follows:

Date.	Amount.	Work performed by—
Average 6 months ending—		
June 30, 1909	$36,833	Quartermaster's department and division engineers.
Dec. 31, 1909	24,328	Quartermaster's department.
June 30, 1910	17,819	Do.

As originally organized, repairs were performed by forces of white and colored artisans in each district, under the supervision of the district quartermaster.

Experience has demonstrated that, with the exception of all but minor repairs, the work can be handled more expeditiously and economically by traveling gangs with picked foremen, under the direct supervision of the constructing quartermaster. The two original gangs have been increased to six, four of carpenters and two of painters, and it is believed that the cost of repairs will be still further reduced during the ensuing year.

MATERIAL AND SUPPLIES.

Three hundred and fifty thousand tons of material, valued at $10,103,552.34, were received from the United States during the year. The value of local purchases, including coal and oil, was $2,094,131.02. The stock carried in storehouses at the end of the fiscal year amounted to $4,691,034.10. The maintenance and distribution of this immense stock is one of the most important duties of this department.

The experiment of annual contracts for standard articles of consumption has worked out satisfactorily. It has diminished the time between the placing of the requisition and the delivery of the material on the Isthmus. Business between Washington and this office has been facilitated. Fewer shortages of stock have occurred during this year than ever before.

The operation of dock 14 was transferred from the Panama Railroad Company to this department on December 1, 1909. A greatly reduced schedule of charges was put into effect, the rate on handling general cargo being reduced from 40 cents per ton to 32 cents per ton.

Since December 1 more than 100,000 tons of material have been handled over this dock by the quartermaster's department at a unit cost of 27 cents per ton, or at a profit over the reduced rates fixed by the commission.

Eighty-seven per cent of the material received goes direct to line storehouses or division engineers, thereby avoiding handling and storage at Mount Hope.

The stock at Mount Hope storehouse proper shows an increase of nearly $300,000 over that carried the year before.

On January 1 the storehouses operated by the Atlantic and Pacific divisions were transferred to this department; those at Balboa, Miraflores, and Gatun were put in charge of storekeepers, who report direct to the chief quartermaster.

The storehouse at Porto Bello was put in charge of the district quartermaster, and that at Cristobal dry dock under the depot quartermaster.

Additional facilities were found necessary at Porto Bello, Gatun, Miraflores, and Balboa to properly care for the increased demands of the work, the amount of business pertaining to material and supplies having doubled at Gatun since January 1.

A transfer of part of the work of the Empire shop to Gorgona necessitated a corresponding transfer of material from the Empire to the Gorgona storehouse. The increase of business in other departments counterbalanced this, and the issues at Empire are approximately the same as before.

A general stock of electrical supplies for the Isthmus is carried at Empire. The Empire car shed was turned over to the storehouse by the central division, and a new lay out of the yard was made, which enables material to be handled with much more facility than before.

Stock carried at Gorgona storehouse has increased from $549,000 to $789,000. The increase of work in the Gorgona shop has carried with it a corresponding increase in the amount and value of the material issued at this storehouse. A lumber shed has been put up and arrangements made to increase the amount of yard space, which was very limited before.

The lumber yard at Balboa has been eliminated. The largest stock in the department is carried in Lirio yard. Another large stock is maintained at Gorgona for the mechanical division. A total of 6,000,000 feet b. m. was on hand in the various yards on June 30.

With the decrease of building operations it was anticipated that there would be a decrease in the amount of lumber required, but the requirements of car-repair work and lock forms have caused a large increase in the amount of lumber purchased. Thirty-one million four hundred and fourteen thousand two hundred and forty-six feet were received during the year, of which 21,703,027 feet came in on the Pacific side. Three hundred and forty-five thousand one hundred and eighty-five tons of coal and 465,921 barrels of oil were used during the year.

In March, circular No. 1 was revised, and a number of changes made in the clerical work pertaining to the issue of material and to cost keeping. The pricing and extending of foreman's orders is now done in the storehouses, and the totals furnished by them are the basis of the material charges of the cost-keeping reports of the various divisions and departments of the commission. Stock cards are being kept up at all storehouses, and frequent test inventories made.

PROPERTY RETURNS.

During the past year 50 semiannual returns of property from 25 accountable officials were audited and settled.

These returns covered the retail issues and transfers of material after receipt on the Isthmus, and included more than 1,000,000 items of property and miscellaneous material purchased and in store on the Isthmus.

A total of 98,724 vouchers, covering approximately 2,000,000 individual issues, were checked and filed in support of returns.

Monthly reports were rendered by the depot quartermaster covering all items received from the United States and for material purchased on the Isthmus. These reports were checked against dealers' bills by the disbursing officer, Washington, for material purchased in the United States, and by the examiner of accounts, Empire, for material purchased on the Isthmus. The reports were then checked by this office as debit vouchers to the semiannual return of the depot quartermaster, thereby initiating accountability for all property purchased.

Respectfully submitted.

C. A. Devol,
Chief Quartermaster.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.

Exhibit 1.—Force actually at work on June 30, 1910.
Exhibit 2.—Statement showing force at work for the Isthmian Canal Commission and Panama Railroad Company from December, 1906, to June, 1910.
Exhibit 3.—Immigration and emigration report, July, 1909, to June, 1910.
Exhibit 4.—Contract laborers brought to the Isthmus by the commission.
Exhibit 5.—Occupants of commission quarters.
Exhibit 6.—Applications for married quarters on file.
Exhibit 7.—Animals in corrals.
Exhibit 8.—Number of buildings on the Canal Zone.
Exhibit 9.—New construction under contract during the fiscal year.
Exhibit 10.—Comparative costs of standard type buildings.
Exhibit 11.—Value of material received during 1909-10, on requisitions of the various departments.
Exhibit 12.—Freight statement.
Exhibit 13.—Important items of material purchased from inception of canal work 1904, to June 30, 1910.
Exhibit 14.—Important items of material received from July 1, 1909, to June 30, 1910 ($100,000 or over).
Exhibit 15.—Important items due on United States requisitions.
Exhibit 16.—Value of stock on hand.

EXHIBIT 1.—*Force actually at work on June 30, 1910.*

Department or division.	Silver employees.													Total silver.	Total gold.	Grand total.
	Monthly.	Artisans.					Laborers.									
							Europeans.		West Indians.							
		44 cents.	32 cents.	25 cents.	20 cents.	16 cents.	20 cents.	16 cents.	20 cents.	16 cents.	13 cents.	10 cents.	7 cents.			
Department of construction and engineering	4,124	18	34	289	646	2,415	3,070	1,878	111	521	2,965	3,564	278	19,913	3,271	23,184
Department of civil administration	182			2	4	18						3		209	335	544
Department of sanitation	692			3	4	4	2	1	1		5	325	6	1,043	360	1,403
Quartermaster's department	1,047	5	3	55	161	174	282	107	36		36	1,011		2,917	237	3,154
Subsistence department	619			1	1									621	53	674
Disbursing office	8													8	21	29
Examiner of accounts	6													6	90	96
Commissary (not included in totals)	462			4	8	42					22	157	65	760	223	983
Panama R. R. Co. (not included in totals)														2,837	572	3,409
Panama R. R. relocation (not included in totals)														1,989	113	2,102
Total	6,678	23	37	350	816	2,611	3,354	1,986	148	521	3,006	4,903	284	24,717	4,367	29,084
Week previous, June 22, 1910	6,656	22	37	349	821	2,634	3,522	1,989	134	567	3,041	5,184	293	25,249	4,339	29,588
Changes	+22	+1		+1	−5	−23	−168	−3	+14	−46	−35	−281	−9	−532	+28	−504
Month previous, May 25, 1910	6,575	22	39	352	888	2,653	3,689	1,994	141	510	3,062	4,961	287	25,173	4,340	29,513
Changes	+103	+1	−2	−2	−72	−42	−335	−8	+7	+11	−56	−58	−3	−456	+27	−429

Exhibit 2.—*Statement showing force at work for the Isthmian Canal Commission and Panama Railroad Company from December, 1906, to June, 1910.*

Year and month.	Commission.			Total Panama Railroad.	Total Panama Railroad and Commission.	Laborers.			
						Europeans.		West Indians.	
	Gold.	Silver.	Total.			20 cents per hr.	16 cents per hr.	13 cents per hr.	10 cents per hr.
1906.									
December	3,881	15,604	19,485	4,416	23,901	1,591	706	211	6,430
1907.									
January	4,033	16,987	21,020	4,796	25,816	1,985	447	213	7,017
Feoruary	4,357	18,680	23,037	4,575	27,612	2,380	442	251	7,227
Marcn	4,411	19,708	24,119	5,249	29,368	2,993	332	282	7,285
April	4,570	19,697	24,267	5,475	29,742	3,106	467	374	6,715
May	4,465	20,105	24,570	4,892	29,462	3,908	411	192	6,281
June	4,404	18,923	23,327	6,119	29,446	3,929	388	205	5,216
July	4,529	19,632	24,161	6,192	30,353	3,980	419	281	4,824
August	4,546	19,487	24,033	5,834	29,867	4,056	428	309	4,347
September	4,638	18,969	23,607	6,238	29,845	4,374	218	515	3,749
October	4,992	20,836	25,828	6,139	31,967	4,839	295	770	4,031
November	4,822	20,507	25,329	6,148	31,477	4,764	292	806	3,663
December	4,668	19,095	23,763	4,940	28,703	4,518	275	852	3,689
1908.									
January	4,935	20,493	25,428	6,557	31,985	4,978	276	905	3,748
February	5,083	20,745	25,828	6,430	32,258	5,016	472	728	3,643
March	4,996	20,556	25,552	7,103	32,655	4,897	510	692	3,677
April	4,950	21,168	26,118	7,052	33,170	4,773	593	729	3,738
May	4,745	21,036	25,881	7,052	32,933	4,400	562	684	4,139
June	4,587	20,991	25,578	5,622	31,200	4,413	500	537	4,616
July	4,477	21,049	25,526	5,794	31,320	4,187	558	516	4,344
August	4,396	21,486	25,882	5,794	31,676	4,505	411	1,374	4,566
September	4,328	21,129	25,457	5,132	30,589	4,865	377	1,263	4,103
October	4,183	20,752	24,935	5,766	30,701	4,793	327	1,343	4,004
November	4,161	19,803	23,964	5,863	29,827	4,422	368	1,593	3,854
December	4,275	20,142	24,417	6,091	30,508	4,617	188	2,010	3,682
1909.									
January	4,295	20,583	24,878	6,393	31,271	4,693	220	2,335	3,560
February	4,334	20,858	25,192	6,623	31,815	4,720	265	1,969	3,315
March	4,381	21,352	25,733	7,263	32,996	4,690	478	1,923	3,124
April	4,355	22,480	26,835	6,864	33,699	4,100	510	5,740	3,229
May	4,262	22,032	26,294	6,365	32,659	3,817	359	2,664	5,646
June	4,166	22,302	26,468	6,472	32,940	3,672	475	1,797	5,370
July	4,198	22,740	26,938	6,963	33,901	3,591	485	3,368	5,881
August	4,070	22,449	26,519	7,223	33,742	3,446	530	3,562	6,137
September	4,191	23,158	27,349	7,861	35,210	3,442	544	3,679	6,351
October	4,376	23,411	27,787	7,618	35,405	3,366	661	3,857	6,072
November	4,372	22,014	26,386	7,422	33,808	3,100	704	3,775	5,475
December	4,339	22,905	27,244	6,701	33,945	3,398	1,113	4,036	5,113
1910.									
January	4,532	25,218	29,750	7,636	37,386	3,641	1,221	4,289	5,578
February	4,602	25,212	29,814	7,644	37,458	3,451	1,135	4,452	5,420
March	4,553	26,284	30,837	7,839	38,676	3,710	1,553	4,587	5,195
April	4,485	24,726	29,211	7,692	36,903	3,652	1,596	4,054	4,874
May	4,368	25,192	29,560	7,236	36,796	3,669	1,936	3,678	5,287
June	4,367	24,717	29,084	6,494	35,578	3,354	1,986	3,675	5,187

EXHIBIT 3.—*Immigration and emigration, July, 1909, to June, 1910.*

Year and month.	Cabin.		Steerage.		Coast towns.	
	Increase.	Decrease.	Increase.	Decrease.	Increase.	Decrease.
1909.						
July	312		1,385		447	
August	79		435		629	
September	453		1,948		122	
October	859		630		440	
November	485		111		267	
December	250		1,569		152	
1910.						
January	530		994		95	
February	34		1,165		69	
March	611		1,492			165
April		81	1,262		1,303	
May		298	652		1,016	
June	130		539		1,023	
Total	3,743	379	12,182		5,563	165
Net increase	3,364		12,182		5,398	

EXHIBIT 4.—*Contract laborers brought to the Isthmus by the Isthmian Canal Commission.*

Country.	1904.	1905.	1906.	1907.	1908.	1909.	1910.	Total.
Spain			1,181	5,291	1,750			8,222
Cuba			500					500
Italy			909	1,032				1,941
France			19					19
Armenia			14					14
Total Europeans			2,623	7,424	1,750			11,797
Barbados	404	3,095	6,510	3,242	2,592	3,605		19,448
Guadaloupe				2,039				2,039
Martinique		2,733	585	2,224				5,542
Jamaica		47						47
Trinidad			1,079				205	1,284
Curaçao			23					23
St. Kitts			933					933
Fortune Island			361					361
Total West Indians	404	5,875	9,491	7,505	2,592	3,605	205	29,667
Costa Rica		244						244
Colombia		1,077	416					1,493
Panama		334	10	13				357
Not classified			69					69
Grand total	404	7,530	12,609	14,942	4,342	3,605	205	43,432

Exhibit 5.—*Occupants of commission quarters, June, 1910.*

Place.	Gold employees.			West Indians.			Europeans.		
	Men.	Women.	Children.	Men.	Women.	Children.	Men.	Women.	Children.
Balboa	264	82	102	174	18	32	229	24	26
Ancon	322	245	106	448	45	14	309	3	2
Corozal	193	59	73	127	4	2	126	1	1
Miraflores	22	2	....	261	9	16	462	3	2
Pedro Miguel	253	81	69	162	42	41	343	11	9
Paraiso	164	86	68	160	116	104	176	11	14
Culebra	366	230	194	400	135	150	593	45	53
Empire	571	311	257	232	116	141	183	63	92
Las Cascadas	232	105	106	211	124	124	497	41	55
Bas Obispo	76	24	17	154	36	50	191	34	26
Gorgona	599	196	214	330	107	153	211	14	13
Tabernilla [a]	142	51	60	471	71	72	676	5	7
Gatun	727	173	160	1,374	20	32	1,409	33	34
Cristobal	979	213	199	989	251	869	303	....	....
Porto Bello [b]	190	16	15	692	....	....	265	....	....
Total	5,100	1,874	1,640	6,185	1,094	1,300	5,973	288	334

[a] Includes San Pablo and Bohio. [b] Includes Nombre de Dios.

There are also 8 Asiatics at Balboa and 68 East Indians at Nombre de Dios.

Exhibit 6.—*Applications for married quarters on file, April, 1910, to June, 1910.*

Stations.	No. 1 list.	No. 2 list.
Balboa	1 (1)	43
Ancon	....	24
Ancon Hospital	1	5
Corozal	2	25
Miraflores	1 (1)	2
Pedro Miguel	4	....
Paraiso	3	38 (8)
Culebra	....	....
Empire	....	....
Las Cascadas	2	5 (4)
Bas Obispo	....	....
Gorgona	....	70 (26)
Tabernilla	....	....
Gatun	3	127 (46)
Cristobal	2	160
Porto Bello	....	26
Total	19 (2)	525 (84)
April 30, 1910	72 (22)	520 (85)
May 30, 1910	37 (3)	516 (89)

Note.—The figures in parenthesis show the number of applicants already occupying regular or non-housekeeping family quarters at stations other than those at which applications are filed.

EXHIBIT 7.—*Animals in corrals June, 1910.*

Stations.	American horses.	Native ponies.	Mules.	Police ponies.	Fire horses foraged.	Private animals.	Total.
Ancon	39	8	135	10	2	32	226
Corozal	3	1	14			10	28
Pedro Miguel	1	2	23	2		22	50
Culebra	8	5	33			21	67
Empire	7	3	49	4		29	92
Las Cascadas	1	2	10	1		8	22
Bas Obispo			9	1		2	12
Gorgona	1		21		2	5	29
Tabernilla			2				2
Gatun	4	3	67	3		10	87
Cristobal	10	1	108	1	1	13	134
Grand total	74	25	471	22	5	152	749

EXHIBIT 8.—*Number of buildings on the Canal Zone, June, 1910.*

Stations.	Isthmian Canal Commission.	French.	Total.
Alhajuela	2	2	4
Ancon	189	42	231
Bailamonos		1	1
Balboa	100	32	132
Bas Obispo	83	177	260
Bohio	1	40	41
Colon Hospital	31	10	41
Corozal	44	29	73
Cristobal	143	116	259
Cruces		1	1
Culebra	218	120	338
Culebra Island	9		9
Empire	205	113	318
Frijoles	1	3	4
Gatun	234		234
Gorgona	155	115	270
Las Cascadas	93	113	206
Miraflores	25	30	55
Nombre de Dios	11		11
Palo Seco	16		16
Panama	1	2	3
Paraiso	106	83	189
Pedro Miguel	98	29	127
Porto Bello	56	1	57
Sabanas	4		4
San Pablo	23	45	68
Tabernilla	62	40	102
Taboga Island	3	3	6
Toro Point	18		18
Grand total	1,931	1,147	3,078

EXHIBIT 9.—*New construction under contract during the fiscal year.*

Building.	Building number.	Location.	Total cost, labor.	Total cost, material.	Total cost.	Total unit cost.
1 type 17 house	224	Ancon	$818.91	$1,097.96	$1,916.87	$1,916.87
3 type 27 houses	225 and 227	....do	2,465.18	3,332.39	5,797.57	1,932.52
2 type 18 houses	184 and 185	Gatun	5,605.86	6,644.19	12,250.05	6,125.02
1 type 10 house	223	Ancon	1,292.94	1,750.59	3,043.53	3,043.53
1 type 18 house	341	Cristobal	2,586.63	3,550.27	6,136.90	6,136.90
3 type 14 houses	187, 188, 189	Gatun	6,877.29	8,383.08	15,260.37	5,086.79
1 type 21 house	74	Corozal	1,845.37	2,118.29	3,963.66	3,963.66
2 type 27 houses	191 and 192	Gatun	1,860.15	3,228.80	5,088.95	2,544.47
1 type 18 house	195	....do	3,162.42	4,307.50	7,469.92	7,469.92
Wards A-B and dining room.	232	Ancon	5,958.60	1,781.57	7,740.17	7,740.17
Attendants' quarters	231	....do	1,087.91	540.49	1,628.40	1,628.40
Engine house and additional work.	156	Gamboa	2,932.87	3,444.98	6,377.85	6,377.85
Oil house	153	....do	201.34	153.10	354.44	354.44
Coaling platform	157	....do	440.64	621.15	1,061.79	1,061.79
Cinder pit	154	....do	586.54	116.55	703.09	703.09
Storehouse and office	155	....do	298.27	186.92	485.19	485.19
Yard office	158	....do	370.76	409.52	780.28	780.28
Schoolhouse	200	Gatun	1,438.33	2,037.87	3,476.20	3,476.20
Market	199	....do	971.97	898.19	1,870.16	1,870.16
Fire station	71	Bas Obispo	463.83	700.97	1,164.80	1,164.80
Schoolhouse	206	Culebra	1,022.63	1,031.33	2,053.96	2,053.96
Young Men's Colored Institute.	207	....do	1,117.88	1,965.55	3,083.43	3,083.43
Fire station	48	Porto Bello	625.61	646.04	1,271.65	1,271.65
Recreation building	75	Corozal	1,962.29	1,992.37	3,954.66	3,954.66
Motor car house	207	Gatun	647.58	756.44	1,404.02	1,404.02
Young Mens' Christian Association clubhouse.	203	....do	7,655.43	13,657.45	21,312.88	21,312.88
Type 27 house	208	Agua Clara Gatun.	1,382.65	974.56	2,357.21	2,357.21
Recreation hall	50	Porto Bello	2,019.24	2,407.35	4,426.59	4,426.59
Commissary building	49	....do	1,613.45	1,757.06	3,370.51	3,370.51
Do	76	Corozal	1,750.86	2,706.53	4,457.39	4,457.39
Storehouse	47	Porto Bello	2,695.67	2,238.73	4,934.40	4,934.40
1 type 18 house	220	Gatun	3,110.53	3,879.25	6,989.78	6,989.78
Do	52	Porto Bello	3,023.18	3,795.69	6,818.87	6,818.87
1 standard laborers' barracks No. 2.	53	....do	632.47	903.67	1,536.14	1,536.14
6 type 14 houses	221-226	Gatun	12,059.89	16,140.23	28,200.12	4,700.02
Stable building No. 1	236	Ancon corral	2,693.35	3,840.45	6,533.80	6,533.80
Stable building No. 2	237	....do	2,681.05	3,994.58	6,675.63	6,675.63
Hospital stable building	239	....do	1,145.87	678.05	1,823.92	1,823.92
Wagon and cart shed	238	....do	1,029.00	1,204.80	2,233.80	2,233.80
Carriage shed	235	....do	588.14	652.04	1,240.18	1,240.18
1 type 27 house	219	Ancon	732.74	1,216.83	1,949.57	1,949.57
Total			91,455.32	111,743.38	203,198.70	
Uncompleted—						
1 type 27 house	6	Toro Point				
2 type 18 houses	4 and 5	....do				
3 type 14 houses	7, 8, and 9	....do				
1 standard laborers' barrack No. 2.		Porto Bello				

EXHIBIT 10.—*Comparative costs of standard type buildings.*

Type.	Number erected by building department 1904–Aug., 1908.	Number erected by contract, 1909–10.	Unit cost. 1905–1908.	Unit cost. 1909–10.	Cost per cubic foot, 1905–1908.	Cost per cubic foot, 1909–10.
14	170	9	$6,808.21	$4,730.64	$0.1290	$0.089
17	66	7	3,093.89	2,165.80	.1727	.120
18	43	6	9,973.42	6,610.89	.0975	.064
10	7	1	5,489.22	3,043.53	.166	.092
21	4	1	6,399.35	3,963.66	.209	.129
Commissaries	11	2	6,845.60	4,123.05		
Young Men's Christian Association clubhouse	4	1	31,170.93	21,312.88	.1666	.0704

EXHIBIT 11.—*Value of material received during 1909–10 on requisitions of the various departments.*

Department.	1909. July.	1909. August.	1909. September.	1909. October.	1909. November.	1909. December.	1910. January.	1910. February.	1910. March.	1910. April.	1910. May.	1910. June.	Total.
Construction and engineering:													
Atlantic division	$150,336.11	$85,542.56	$196,994.87	$169,183.35	$165,266.27	$228,400.58	$110,175.76	$157,495.86	$262,378.60	$212,183.25	$197,972.70	$336,659.53	$2,272,589.44
Central division	13,949.98	3,284.28	5,714.90	8,564.97	20,874.87	8,734.18	14,511.29	11,559.51	13,250.04	12,051.93	84,199.67	12,085.59	208,826.21
Pacific division	123,746.70	144,860.69	89,577.14	191,954.04	138,974.63	150,144.23	376,759.18	91,629.92	189,698.87	124,777.48	141,945.40	121,700.89	1,885,769.17
Mechanical division	52,379.44	172,803.70	100,311.12	93,696.79	131,492.45	73,362.57	131,659.57	36,947.88	65,400.14	16,872.94	122,618.94	118,720.30	1,116,292.84
Chief engineer	499.45	1,115.44	1,344.90	1,542.77	1,307.01	814.90	918.41	198.07	928.67	492.91	3,032.37	836.44	12,671.34
Total	340,911.68	407,606.67	393,942.93	464,941.92	457,915.23	461,456.46	634,024.21	297,831.24	531,656.32	366,378.51	549,769.08	432,002.75	5,496,149.00
Quartermaster's:													
Depot quartermaster	580,285.23	403,044.07	274,875.85	284,824.42	314,976.89	326,825.70	235,659.19	288,177.40	502,987.21	281,340.15	376,104.05	575,156.67	4,444,256.83
Printing plant	3,499.59	3,704.91	1,459.72	1,971.40	1,490.27	1,973.68	3,542.82	3,693.32	6,726.64	957.90	5,776.05	2,529.43	37,325.73
Total	583,784.82	406,748.98	276,335.57	286,795.82	316,467.16	328,799.38	239,202.01	291,870.72	509,713.85	282,298.05	381,880.10	577,686.10	4,481,582.56
Subsistence	577.92												577.92
Sanitary	2,901.23	6,146.43	9,737.12	3,240.91	4,106.60	9,717.80	6,602.15	13,227.81	14,556.90	13,393.84	8,130.52	2,805.87	94,567.18
Civil administration	5,685.13	1,068.59	1,929.24	515.58	4,611.85	169.03	711.37	315.44	719.50	3,139.75	1,556.59	58.27	20,480.34
Disbursing officer			882.00		260.00							10.80	1,152.80
Examiner of accounts	1,092.95	532.36	1,355.00		1,723.29			1,445.00	1,230.00	325.50	466.42	872.02	9,042.54
Grand total	934,953.73	822,103.03	684,181.86	755,494.23	785,084.13	800,342.67	880,539.74	604,690.21	1,057,876.57	665,535.65	941,802.71	1,013,435.81	10,103,552.34
Local purchases—Isthmus	150,976.48	21,011.70	232,655.22	186,277.51	162,923.49	190,847.55	186,027.92	141,109.96	161,597.11	202,747.10	198,606.06	259,350.92	2,094,131.02

The local purchases are composed of the following items:

Coal purchased from Panama Railroad	$1,374,229.21
Miscellaneous purchases from Panama Railroad and commissary	206,367.25
Crude oil from Union Oil Company	476,174.66
Miscellaneous from local merchants	19,000.27
Transfer of printing plant from Panama Railroad Company	18,250.19
Postage stamps	84.00
United States Marine Corps	25.44
Total	2,094,131.02

EXHIBIT 12.—*Freight statement, July 1, 1909, to June 30, 1910.*

Steamship line.	Steamers.	General cargo.	Lumber.	Ties.		Piling.	Total weight.	Total weight.
				Pieces.	Feet B. M.			
		Pounds.	*Ft. B. M.*			*Lin. ft.*	*Pounds.*	*Tons.*
Panama R. R. steamship	86	[a]436,144,663	91,088				436,450,000	218,225
United Fruit Co.	73	26,940,840	5,056,325	49,071	1,766,885	97,710	47,694,000	23,847
Hamburg-American	52	4,916,000					4,916,000	2,458
Royal Mail	23	254,000					254,000	127
Leyland	16	774,000					774,000	387
Pacific Mail	20	155,295	4,232				168,000	84
Tramps (Pacific)	14		21,698,795	28,528	848,708		78,226,000	39,113
Tramps (Atlantic)	41	86,738,203	4,563,806	269,123	9,826,812	516,366	130,758,000	65,379
Total	325	555,923,001	31,414,246	346,722	12,442,405	614,076	699,240,000	349,620

[a] Includes 885,077 barrels cement. United Fruit Company also brought 68 head of stock. In addition to the above, there were received 1 tug and 1 dredge. Total weight shown above does not include weight of piling.

EXHIBIT 13.—*Important items of material purchased from inception of canal work, 1904 to June 30, 1910.*

Article.	Quantity.	Value.
Barges	40	$884,130.00
Boats, tug	8	481,000.00
Brick, building, fire, and paving		230,367.80
Cableways	7	365,050.90
Cars	3,944	4,369,989.79
Cement	[a]1,145,187	1,397,320.02
Compressors, air	28	125,504.77
Cranes	60	416,840.25
Dredges	13	1,892,788.00
Drills, rock	725	288,376.59
Explosives:		
Dynamite	[b]31,645,900	3,564,920.30
Other blasting supplies		408,865.59
Forage and corral supplies		545,903.55
Furniture:		
Married quarters		259,885.55
Bachelor quarters		145,791.50
Hospital quarters		74,850.69
Laborers' quarters		208,809.00
		689,336.74
Live stock:		
Horses		39,212.50
Mules		99,572.00
Cows		8,650.00
		147,434.50
Locomotives	189	1,942,502.00
Lumber	[c]154,309,680	3,515,460.18
Material for locks		614,091.79
Piling	92,644	975,492.40
Plants:		
Material handling (3)		689,358.60
Rock crusher (4)		200,164.68
Filtration (3)		33,260.00
Pumping (2)		14,950.00
Boiler (2)		114,961.00
Hydraulic dredging (1)		192,868.00
		1,245,562.28
Rails, steel	[d]56,424	1,778,795.99
Roofing, corrugated iron		456,740.98
Screening, wire		388,979.25
Shovels, steam	102	1,094,879.96
Spreaders, earth	24	124,509.00
Ties, cross and switch	1,453,648	1,226,728.57
Unloaders	29	158,839.00

[a] Barrels. [b] Pounds. [c] Feet board measure. [d] Gross tons.

EXHIBIT 14.—*Important items of material received from July 1, 1909, to June 30, 1910, ($100,000 and over).*

Article.	Quantity.	Value.
Boat, tug	1	$75,500.00
Cars, dump, and flat	181	183,579.00
Cement	[a] 885,077	969,520.62
Cranes, derricks, and hoisting engines	35	135,191.50
Dredge, 1 pipe line	1	158,000.00
Dynamite	[b] 10,403,800	1,143,623.80
Other blasting supplies		106,256.16
Lumber	[c] 31,414,246	711,386.61
Material for locks and lock work:		
Movable towers (12)		127,768.48
Ironwork for locks		393,791.74
Collapsible steel forms		92,531.57
		614,091.79
Oils and greases (lubricants)		127,250.59
Piling	22,057	179,590.52
Plants:		
Rock crushers (2)		90,905.04
Material handling		294,328.00
Filtration (1)		8,260.00
Pumping (2)		14,950.50
Hydraulic dredging (1)		192,868.00
		601,311.54
Rails, steel	[d] 9,000	376,750.00
Steel, flat, round, square, tool, etc	[e] 471,913	310,561.50
Ties, cross and switch	346,722	244,789.41

[a] Barrels. [b] Pounds. [c] Feet, board measure. [d] Gross tons. [e] Pieces.

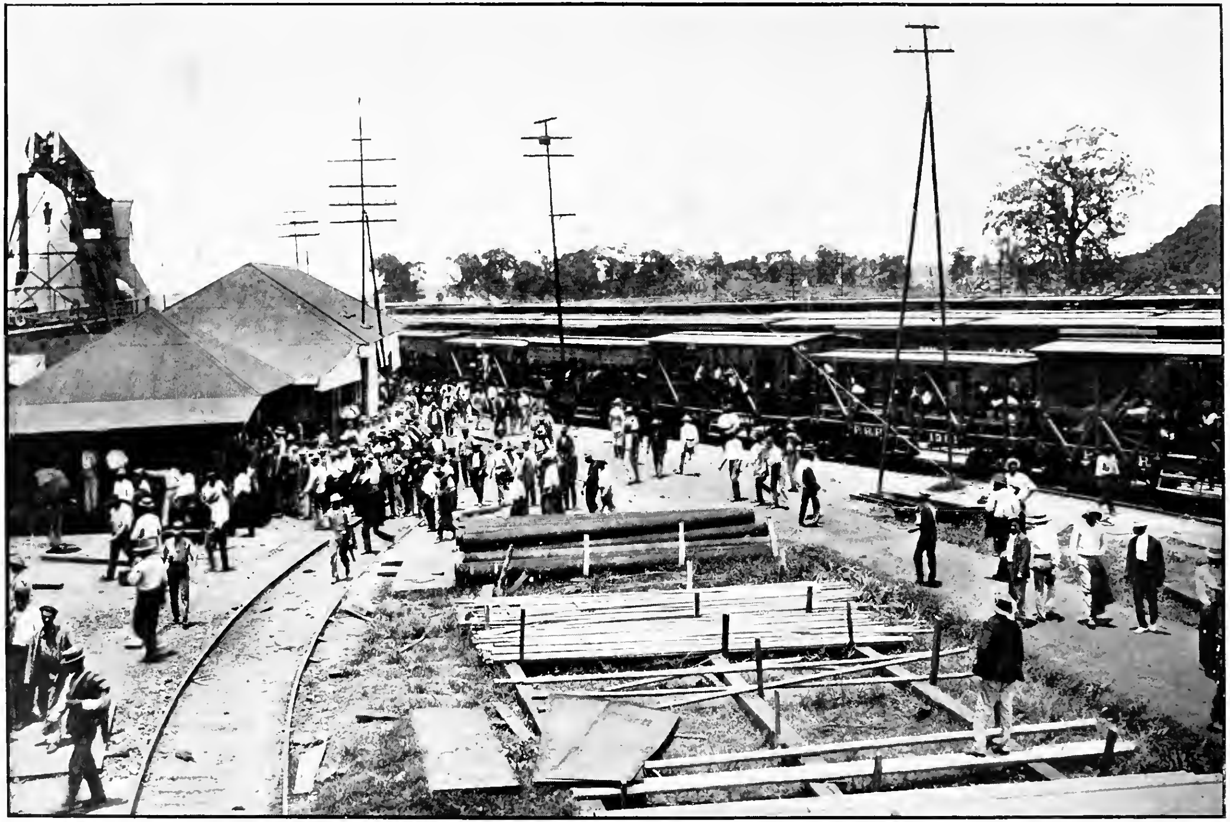
EXHIBIT 15.—*Important items due on United States requisitions, June 30, 1910.*

Article.	Quantity.	Value.
Barges, sand and rock	4	$208,400.00
Boat, tug	1	86,234.00
Cars, dump:		
12-yard	100	105,000.00
19-yard	250	426,247.00
Cement	[a] 3,624,923	3,824,293.63
Cranes:		
Locomotive coaling (3)		23,123.50
75-ton wrecking (1)		14,250.00
		37,373.50
Dredge, steam ladder	1	450,000.00
Dynamite	[b] 13,727,000	1,654,129.00
Other blasting supplies		111,605.29
Lumber	[c] 12,472,726	261,927.25
Material for locks:		
Fixed irons for rising stem gate valves		358,000.00
Gate leaves (92)		5,375,000.00
Ironwork for locks		152,506.42
Machinery for operating stony gate valves		426,000.00
		6,311,506.42
Piling	14,807	168,995.27
Rail, steel	[d] 5,275	165,371.25
Ties, cross and switch	258,855	199,691.95
Other track material		118,309.75
Wheels, car	6,550	51,487.00

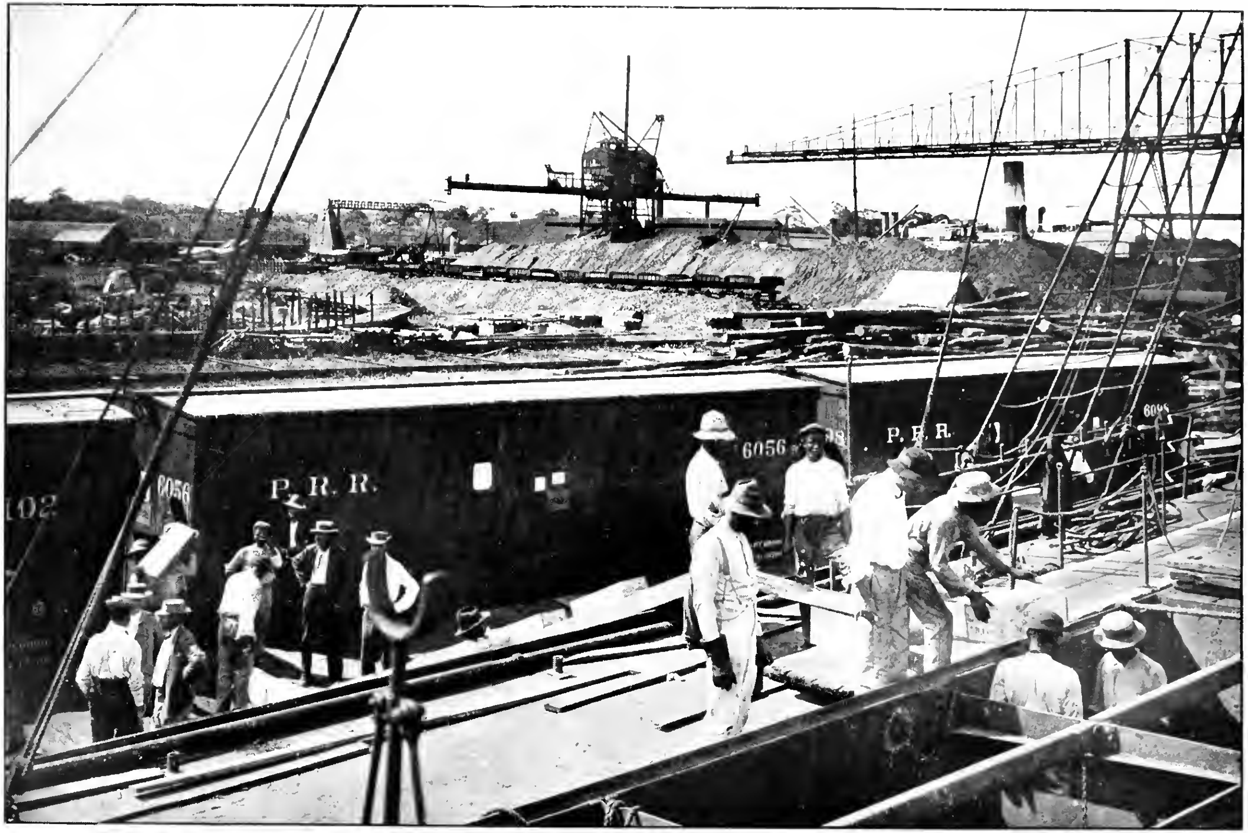
[a] Barrels. [b] Pounds. [c] Feet, board measure. [d] Gross tons.

EXHIBIT 16.—*Value of stock on hand, June 30, 1910.*

Storehouse.	Value.	Storehouse.	Value.
Mount Hope	$1,740,673.57	Culebra	$2,591.67
Dry dock	162,010.11	Pedro Miguel	13,140.95
Porto Bello	130,191.34	Miraflores	146,380.05
Gatun	313,084.83	Corozal	4,156.09
San Pablo	6,676.91	Ancon	21,346.54
Gorgona	789,272.74	Balboa	247,704.87
Bas Obispo	1,348.40		
Las Cascadas	14,647.01	Total	4,691,034.10
Empire	1,097,809.02		



LABOR TRAIN ARRIVING AT DRY DOCK, CRISTOBAL, 1910.



UNLOADING DYNAMITE FROM SHIP AT PIER 13, MOUNT HOPE, 1910.

QUARTERMASTER'S CORRAL AT ANCON, 1910.

APPENDIX L.

REPORT OF MAJ. E. T. WILSON, U. S. ARMY, SUBSISTENCE OFFICER, IN CHARGE OF SUBSISTENCE DEPARTMENT.

Isthmian Canal Commission,
Subsistence Department,
Cristobal, August 1, 1910.

Sir: I have the honor to submit the following annual report of the operations of the subsistence department for the fiscal year ending June 30, 1910.

On June 30 this department was operating the Hotel Tivoli, 18 Isthmian Canal Commission hotels, 19 European laborers' messes, and 20 common laborers' kitchens, an increase of 1 hotel and a decrease of 1 kitchen over last year.

The total revenue for the year from the line hotels, messes, and kitchens was $1,350,658.05, a decrease of $168,620.08 over last year. The total expenses were $248,313.71, a decrease of $46,602.18 over last year. The revenues fell off 11 per cent, but the expenses fell off 15.7 per cent. The revenue of the department since July, 1908, has fallen off 42.6 per cent, while the percentage of expense to revenue during the same time has decreased from 20 per cent to 18.1 per cent. The per cent of expense to revenue is 1 per cent less this year than last.

The expense for wages and salaries last year was $236,955.52, and this year $191,438.11, a decrease of 19.5 per cent. The proportion of pay roll to revenue for this year is 14.1 per cent, and last year was 15.5 per cent, a decrease of 1.4 per cent.

The total number of meals served at Isthmian Canal Commission hotels was 2,176,451. The cost for supplies was 24.87 cents, and the expense was 6.23 cents per meal, a decrease in expense of 0.69 cent over last year, and the cost of supplies increased 1.33 cents per meal, making a total increase of 2.02 cents per meal which has gone into food—a total increase of $43,964.31 in food supplies furnished over last year.

The total number of rations furnished in European laborers' messes was 1,092,487, which cost 30.18 cents per ration for food and 6.66 cents per ration for expense. The number of rations served decreased 78,690, the food cost decreased 0.77 cent per ration, but the expense also decreased 0.6 cent per ration.

The number of rations served in common laborers' kitchens was 781,746, which cost 22.66 cents for food and 4.63 cents for expense. The number of rations decreased this year over last 616,746. The cost for supplies was 0.14 cent greater this year than last, but the cost of service was 0.09 cent less. There has been a constant decrease in the number of laborers taking their meals at the kitchens, the attendance in June, 1910, being about 50 per cent less than in June, 1909.

The average daily attendance during June, 1910, in kitchens was 1,496; the average daily attendance in messes, 3,178; and the average daily attendance in the line hotels, 1,915.

The following table shows the relative value of food consumed per day per person in the Isthmian Canal Commission hotels. This table was made up by taking periods in each month and averaging them. The actual cost would be about 6 per cent less.

	Cents.
Meats, fresh	25. 92
Fruits and vegetables, fresh	10. 66
Miscellaneous supplies	6. 93
Butter	6. 18
Eggs	5. 91
Fruits and vegetables, canned	5. 40
Meats, cured	4. 47
Bread	2. 73
Milk	2. 37
Ice cream	2. 25
Sugar	2. 19
Tea, coffee, and cocoa	1. 71
Flour	1. 71
Meats, canned	1. 05
Total	79. 50

In addition to the foregoing the consumption of ice was 3.45 pounds per day.

The following table shows the relative weight and value of the ration supplied European laborers' messes:

Article.	Weight.	Cost.
	Pounds.	*Cents.*
Meats, fresh	1. 06	10. 81
Bread	1. 61	6. 60
Miscellaneous	1. 05	5. 05
Fruits and vegetables, fresh	. 60	1. 76
Sugar	. 29	1. 31
Meats:		
Canned	. 07	1. 20
Cured	. 08	1. 07
Tea, coffee, and cocoa	. 04	. 88
Fruits and vegetables, canned	. 05	. 37
Milk	. 02	. 24
Flour	. 03	. 14
Butter	. 01	. 14
Eggs	. 00	. 01
Total	4. 91	29. 58

In addition to the foregoing, 1.38 pounds of ice were consumed, which cost 0.56 cent.

The following table shows the average weight and cost of supplies per ration for the common laborers' kitchens:

Article.	Weight.	Cost.
	Pounds.	*Cents.*
Meats, fresh	. 73	7. 02
Bread	1. 11	4. 46
Miscellaneous	. 77	3. 13
Fruits and vegetables, fresh	. 94	1. 90
Meats, cured	. 21	1. 82
Sugar	. 36	1. 42
Tea, coffee, and cocoa	. 03	. 59
Flour	. 15	. 59
Meats, canned	. 02	. 52
Milk	. 03	. 33
Fruit and vegetables, canned	. 05	. 32
Butter	. 01	. 16
Total	4. 41	22. 26

It is a coincidence that the net weight of the ration furnished the European laborer is exactly equal to the gross weight of the United States Army garrison ration, and the net weight of the ration furnished the negro laborer is exactly equal to the gross weight of the United States Army field ration.

The foregoing costs are approximate only, as they were made from a selection of periods during which the average weights and prices were taken. Consequently the figures given above as to daily weights and costs will not check with the total costs given elsewhere. It will be seen, however, that a very well-balanced ration is provided for all the line hotels, messes, and kitchens.

The following table shows the value of the principal articles consumed in the Isthmian Canal Commission hotels, messes, and kitchens during the year:

Beef, fresh	$334, 304. 11
Bread	124, 798. 64
Eggs	55, 884. 70
Poultry	55, 316. 25
Potatoes, white	46, 431. 00
Butter	42, 435. 05
Sugar	38, 818. 31
Milk	22, 844. 40
Beans	22, 531. 69
Pork, fresh	22, 093. 00
Veal, fresh	18, 404. 05
Flour	17, 851. 56
Rice	17, 675. 46
Coffee	17, 141. 78
Lard	14, 780. 16
Mutton, fresh	12, 332. 58
Bacon	11, 221. 89
Fish, cured	10, 463. 70
Ham	10, 230. 99
Fish, fresh	9, 240. 92
Potatoes, sweet	8, 252. 49
Yams	6, 969. 96
Cocoa	5, 382. 51
Mutton, salt	4, 361. 82
Tea	3, 739. 05
Beef, salt	852. 00
Pork, salt	688. 09
Total	933, 046 16

The following table shows the relative net weights of some of the principal articles consumed during the year:

Bread	pounds	3, 119, 966
Beef, fresh	do	2, 621. 993
Potatoes, white	do	1, 688, 400
Sugar	do	913, 372
Rice	do	589, 182
Potatoes, sweet	do	471, 571
Flour	do	446, 289
Beans	do	360, 507
Yams	do	253, 453
Milk	tins	228, 444
Poultry	pounds	213, 265
Eggs	dozen	163, 167
Veal, fresh	pounds	133, 821
Lard	do	123, 168
Butter	do	121, 243
Pork, fresh	do	110, 465
Fish, cured	do	107, 320

Coffee	pounds..	97,953
Mutton, fresh	do....	94,866
Fish, fresh	do....	71,084
Mutton, salt	do....	60,163
Ham	do....	48,719
Bacon	do....	45,341
Cocoa	do....	25,631
Tea	do....	10,683
Beef, salt	do....	10,650
Pork, salt	do....	5,293

As a result of the year's operations the loss on Isthmian Canal Commission hotels was $22,168.71. The profit on the European laborers' messes was $34,504.86. The profit on common laborers' kitchens was $21,211.97.

On November 1, 1909, I made a general reduction in the rates of the Hotel Tivoli amounting to about 20 per cent. The profit for the year resulting from the operation of the Hotel Tivoli was $4,574.23.

The following is a comparative statement of the profit and loss of the Hotel Tivoli by months for this year and last year:

	1908-9.		1909-10.	
	Profit.	Loss.	Profit.	Loss.
July	$737.27			$341.72
August		$1,038.03		2,396.83
September		2,002.33		1,727.44
October		906.01		2,776.61
November		118.23		197.67
December	1,048.69			1,158.76
January	2,373.17		$1,618.04	
February	4,614.41		3,827.04	
March	3,787.06		4,406.39	
April	1,721.22		2,278.77	
May		366.58	1,146.61	
June		462.69		103.59
Net profit	9,387.95		4,574.23	

I attach hereto summary of operations for the Isthmian Canal Commission hotels, messes, and kitchens, which does not include the Hotel Tivoli, and a separate summary for the Hotel Tivoli.

As this organization provides food for as large a number of laborers as will probably ever be gathered under one organization again some facts relative to its organization and methods may be of public benefit, and I think a résumé of its organization and business methods may appropriately be included in this statement that the benefits and knowledge obtained by us may be permanently recorded for the benefit of those who may have a similar task to perform, even if on a smaller scale.

Very respectfully,

Eugene T. Wilson,
Major, Coast Artillery Corps,
Subsistence Officer.

Col. Geo. W. Goethals, *U. S. Army,*
Chairman and Chief Engineer,
Culebra, Canal Zone.

TABLE 1.—*Summary operations, hotels, messes, and kitchens, July 1, 1909, to June 30, 1910.*

	1909.						1910.						Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	
Supplies on hand and in transit	$23,139.95	$19,594.17	$19,385.69	$20,449.46	$19,387.78	$22,633.75	$23,516.87	$23,090.59	$23,093.97	$23,294.70	$21,672.10	$22,765.11	$262,024.14
Purchases	87,640.20	89,226.54	89,784.50	91,006.69	92,813.27	93,678.86	93,791.19	85,822.12	91,220.45	88,306.95	90,369.27	85,824.02	1,079,484.06
Transfers	36,411.70	42,402.96	44,709.61	44,340.23	42,148.72	43,589.79	41,404.43	37,093.75	42,077.08	39,143.83	38,379.01	37,443.92	489,145.03
Discount	4,470.42	4,692.75	4,708.33	4,799.12	5,006.97	4,986.96	4,981.38	4,562.10	5,705.89	5,492.33	5,455.02	4,275.83	59,137.10
Total to account for	151,662.27	155,916.42	158,588.13	160,595.50	159,356.74	164,889.36	163,693.87	150,568.56	162,097.39	156,237.81	155,875.40	150,308.88	1,889,790.33
Transfers	36,412.60	42,395.76	44,709.61	44,340.23	42,148.72	43,589.79	41,404.43	37,093.75	42,086.68	39,143.83	38,381.01	37,443.92	489,150.33
Cleaning	587.51	611.25	546.51	607.22	603.08	639.84	687.41	705.39	777.01	838.42	883.37	904.79	8,391.80
Discounts allowed	4,470.42	4,692.75	4,708.33	4,799.12	5,006.97	4,986.96	4,981.38	4,562.10	5,705.89	5,492.33	5,455.02	4,275.83	59,137.10
Credit notes	189.33	245.89	359.35	460.20	1,334.27	429.00	1,056.78	406.66	321.75	387.27	336.44	317.15	5,844.09
Pay-roll deductions	.92	7.60	4.96	4.20	11.85	6.44	2.96	2.15	1.22	1.60	.17	.96	45.03
Supplies on hand and in transit	19,594.17	19,385.69	20,449.46	19,387.78	22,633.75	23,516.87	23,090.59	23,093.97	20,565.17	21,672.10	22,765.11	22,271.10	258,425.76
Total issues	61,254.95	67,338.94	70,778.22	69,598.75	71,738.64	73,168.90	71,223.55	65,864.02	69,457.72	67,535.55	67,821.12	65,213.75	820,994.11
Supplies consumed	90,407.32	88,577.48	87,809.91	90,996.75	87,618.10	91,720.46	92,470.32	84,704.54	92,639.67	88,702.26	88,054.28	85,095.13	1,068,796.22
Expenses:													
Equipment	259.31	371.98	64.12	100.79	277.95	478.31	233.60	99.79	598.65	175.18	329.93	301.58	3,291.19
Equipment, incidentals, and repairs	54.62	154.46	166.89	95.98	155.13	175.33	176.37	133.40	167.92	215.94	114.17	140.76	1,750.97
Pay roll—													
Office and general	3,595.92	3,408.52	3,510.43	3,438.12	3,609.76	3,663.54	3,228.31	3,327.61	3,089.25	3,541.60	2,544.80	2,700.35	39,658.21
Help	12,939.49	12,932.07	12,801.94	12,950.24	12,474.57	12,564.20	12,705.51	12,855.84	12,476.03	12,506.56	12,446.39	12,327.06	151,779.90
Transportation and utility	1,759.30	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	1,768.49	515.35	19,959.55
Coal	762.33	793.67	836.37	781.53	740.01	750.01	729.81	746.77	766.35	770.83	761.58	563.41	9,002.67
Laundry	932.75	997.44	1,069.15	1,106.54	1,084.63	1,100.62	1,169.09	1,065.33	1,263.86	926.36	903.57	1,068.73	12,688.07
Cleaning	587.51	611.25	546.51	607.22	603.08	639.84	687.41	705.39	777.01	838.42	883.37	904.79	8,391.80
Electric light	113.65	167.60	5.25	155.85	155.85	298.50	151.05	151.05	151.05	151.05	151.05	139.40	1,791.35
Total	21,004.88	21,005.48	20,769.15	21,004.76	20,869.47	21,438.84	20,849.64	20,853.67	21,058.61	20,894.43	19,903.35	18,661.43	248,313.71
Total cost of operation	111,412.20	109,582.96	108,579.06	112,001.51	108,487.57	113,159.30	113,319.96	105,558.21	113,698.28	109,596.69	107,957.63	103,756.56	1,317,109.93
Revenue	114,090.70	109,803.02	112,794.45	113,214.65	106,512.32	112,644.55	118,580.59	108,817.83	121,239.81	114,401.52	112,360.03	106,198.58	1,350,658.05
Profit	2,678.50	220.06	4,215.39	1,213.14			5,260.63	3,259.62	7,541.53	4,804.83	4,402.40	2,442.02	33,548.12
Loss					1,975.25	514.75							

TABLE 2.—*Operation Hotel Tivoli, July 1, 1909, to June 30, 1910.*

	1909.						1910.						Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	
Supplies on hand and in transit	$3,362.00	$2,754.24	$2,338.52	$2,316.12	$2,060.14	$2,718.86	$2,366.49	$2,558.97	$2,411.39	$2,387.23	$2,463.11	$2,293.55	$30,030.62
Purchases	5,383.88	5,036.41	4,582.98	4,664.46	5,772.00	4,992.00	5,771.23	5,834.93	6,483.23	5,564.02	4,779.03	3,777.32	62,641.49
Transfers	.90								9.60		2.00		12.50
Total to account for	8,746.78	7,790.65	6,921.50	6,980.58	7,832.14	7,710.86	8,137.72	8,393.90	8,904.22	7,951.25	7,244.14	6,070.87	92,684.61
Supplies to quarters	60.76	92.36	103.21	104.91	124.97	152.78	136.26	139.14	138.98	144.39	151.12	129.07	1,555.17
Supplies to cleaning	137.98	55.22	39.58	44.93	44.42	44.49	47.96	44.76	38.23	42.81	36.79	33.16	533.61
Supplies on hand and in transit	2,754.24	2,338.52	2,316.12	2,060.14	2,718.86	2,366.49	2,558.97	2,411.39	2,387.23	2,463.11	2,293.55	2,064.20	28,732.82
Commissary credit notes	71.36	153.10	8.29	14.58	18.49	20.27	5.63	47.75		5.17	6.52	2.85	354.01
Pay-roll deductions	.83	.91	3.71	.17	.66				1.38			.24	7.90
Transfers		7.20											7.20
Corrections										5.00	.33		5.33
Total issues	3,025.17	2,647.31	2,470.91	2,224.73	2,907.40	2,584.53	2,748.82	2,643.04	2,565.82	2,660.48	2,488.31	2,229.52	31,196.04
Total supplies consumed	5,721.61	5,143.34	4,450.59	4,755.85	4,924.74	5,126.33	5,388.90	5,750.86	6,338.40	5,290.77	4,755.83	3,841.35	61,488.57
Expense:													
Equipment	355.16	427.74	103.34	137.68	59.35	73.89	167.92	315.54	20.64	64.56	156.84	15.94	1,898.60
Equipment, incidental	111.68	81.52	145.16	68.20	216.03	256.45	153.33	99.81	176.14	271.50	75.71	149.11	1,804.64
Laundry	469.73	428.91	409.72	386.11	407.78	432.47	505.81	503.19	568.74	520.01	412.86	461.00	5,506.33
Cleaning	60.76	55.22	39.58	44.93	44.42	44.99	47.96	44.76	38.23	42.81	36.79	33.16	533.61
Supplies to quarters	137.98	92.36	103.21	104.91	124.97	152.78	136.26	139.14	138.98	144.39	151.12	129.07	1,555.17
Transportation and utility	161.33	152.14	152.14	152.14	152.14	152.14	152.14	152.14	152.14	152.14	152.14	11.28	1,694.01
Coal	125.53	46.55	46.55	46.55	46.55	46.55	46.55	46.55	46.55	46.55	46.55	84.52	675.55
Wages, hotel help	3,128.42	2,621.28	2,614.62	2,731.96	2,636.70	2,471.59	2,457.31	2,310.73	2,319.84	2,175.48	1,823.13	2,033.03	29,324.09
Proportion, general force	207.21	181.43	180.40	191.39	194.47	193.35	174.92	222.04	265.60	257.97	174.29	167.49	2,410.56
Miscellaneous	163.20	168.20	165.00	113.20	128.70	192.40	123.70	118.20	28.50	10.00	50.60	10.00	1,271.70
Electric light and power	150.60	213.95		160.75	195.25	393.30	172.25	122.10	238.75	189.85	180.95	145.04	2,162.79
Less equipment returned						**504.55**			**206.40**		133.75		**844.70**
Total	5,071.60	4,469.30	3,959.72	4,137.82	4,206.36	3,905.36	4,138.15	4,074.20	3,787.71	3,875.26	3,127.23	3,239.64	47,992.35
Total cost of operation	10,793.21	9,612.64	8,410.31	8,893.67	9,131.10	9,031.69	9,527.05	9,825.06	10,126.11	9,166.03	7,883.06	7,080.99	109,480.92
Revenue:													
Coupons	1,337.10	1,127.10	1,194.30	866.70	933.00	751.80	944.70	752.40	825.90	703.80	692.50	573.50	10,702.80
Cash	8,756.91	6,473.11	5,346.12	5,994.92	6,182.70	7,833.90	10,385.20	12,881.10	13,435.30	10,612.20	7,992.17	7,629.20	103,522.83
Credit outstanding accounts	192.23		87.83		1,809.33				246.60	121.55	334.00		2,791.54
Credit D. O. collections	165.25	3.75	53.92	52.25	8.40	1.73	1,319.90	69.49	24.70	8.50	11.70	16.00	1,735.59
Debit outstanding accounts		**388.15**		802.44		**714.50**	**1,504.71**	**50.89**				**1,228.70**	**4,689.39**

Debit adjustments										1.25	1.95	12.60	15.80
Credit adjustments			.70	5.63							1.25		7.58
Total revenue	10,451.49	7,215.81	6,682.87	6,117.06	8,933.43	7,872.93	11,145.09	13,652.10	14,532.50	11,444.80	9,029.67	6,977.40	114,055.15
Subsistence:													
Profit								819.84	981.15				
Loss	2,232.95	2,403.04	4,001.33	2,949.92	1,761.04	1,890.27	161.34			676.33	271.78	1,168.87	15,715.88
Cigar stand:													
Profit	289.91		145.08	95.02	314.86	79.15	59.70	311.19	434.76	340.29	127.49		2,041.74
Loss		129.10										26.21	
Quarters, profit	1,601.32	135.31	2,128.81	78.29	1,248.51	652.36	1,719.68	2,696.01	2,990.48	2,614.81	1,290.90	1,091.89	18,248.37
Net profit							1,618.04	3,827.04	4,406.39	2,278.77	1,146.61		4,574.23
Loss	341.72	2,396.83	1,727.44	2,776.61	197.67	1,158.76						103.59	
Meals served		6,553	6,583	6,211	7,155	6,452	8,574	9,817	11,381	8,836	6,221	5,904	
Cost supplies per meal		$69.90	$63.90	$72.50	$68.80	$74.06	$56.75	$58.58	$51.19	$57.12	$71.09	$57.11	
Cost service per meal		36.90	31.10	33.80	29.60	26.35	24.91	22.94	16.61	22.94	25.26	28.43	
Total cost per meal		106.86	95.00	106.30	98.40	100.41	81.66	81.52	67.80	80.06	96.35	85.54	

TABLE 3.—*Operations, line hotels, July 1, 1909, to June 30, 1910.*

	1909.						1910.						Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	
Inventories and in transit	$18,823.10	$16,147.12	$17,443.59	$18,618.15	$17,639.15	$20,491.65	$21,358.12	$20,999.33	$21,050.42	$18,372.33	$19,670.26	$20,626.94	$231,240.16
Purchases	65,151.60	80,097.77	81,206.24	82,050.40	84,392.10	84,414.83	82,335.87	74,961.85	79,502.31	79,623.62	78,955.45	75,860.65	948,552.69
Transfers	2,215.04	5,165.00	4,734.28	5,081.76	5,850.03	6,295.04	6,157.43	5,297.83	6,042.88	4,791.62	5,676.30	5,874.56	63,181.77
Discount	3,398.36	4,239.92	4,288.64	4,361.35	4,580.73	4,525.25	4,411.11	4,025.83	4,946.71	5,607.48	4,754.71	3,773.68	52,913.77
Total to account for	89,588.10	105,649.81	107,672.75	110,111.66	112,462.01	115,726.77	114,262.53	105,284.84	111,542.32	108,395.05	109,056.72	106,135.83	1,295,888.39
Supplies transferred	24,518.29	38,415.81	41,719.45	40,789.94	38,986.59	40,151.33	38,472.94	34,441.42	39,356.44	36,602.16	35,976.83	34,967.37	444,398.57
Cleaning	350.30	382.07	325.53	366.01	354.76	386.58	439.78	436.66	478.13	508.63	545.20	588.63	5,162.28
Discounts allowed	3,490.40	3,638.10	3,658.45	3,731.15	3,905.90	3,817.09	3,819.16	3,580.43	4,259.78	4,212.01	4,413.31	3,533.35	46,059.13
Credit notes	176.93	218.60	337.38	446.71	1,253.52	423.39	1,016.10	363.37	321.75	377.12	332.81	278.91	5,546.59
Pay-roll deductions				3.24		4.75	.66			1.60	.17		10.42
Inventories and in transit	16,147.12	17,443.59	18,618.15	17,639.15	20,491.65	21,358.12	20,999.33	21,050.42	18,372.33	19,357.50	20,626.94	20,679.23	232,783.53
Total issues	44,683.04	60,098.17	64,658.96	62,976.20	64,992.42	66,141.26	64,747.97	59,872.30	62,788.43	61,059.02	61,895.26	60,047.49	733,960.52
Supplies consumed	44,905.06	45,551.64	43,013.79	47,135.46	47,469.59	49,585.51	49,514.56	45,412.54	48,753.89	47,336.03	47,161.46	46,088.34	561,927.87
Expenses:													
Pay roll—													
Office and general	1,717.94	1,654.14	1,606.66	1,693.12	1,879.47	1,881.98	1,700.67	1,716.38	1,580.77	1,771.50	1,288.19	1,378.52	19,869.34
Hotel	7,504.60	7,497.79	7,586.57	7,822.54	7,813.82	7,752.75	7,693.41	7,942.00	7,775.23	7,818.57	7,741.88	7,601.23	92,550.39
Transportation and utility	848.75	858.51	813.26	882.29	932.70	917.54	955.18	935.26	915.57	884.60	895.24	51.16	9,890.06
Laundry	884.41	955.60	1,017.75	1,055.31	1,034.58	1,022.95	1,099.95	976.41	1,117.62	868.18	854.02	1,017.35	11,904.13
Cleaning	350.30	382.07	325.53	366.01	354.76	386.58	439.78	436.66	478.13	508.63	545.20	588.63	5,162.28
Total expense	11,306.00	11,348.11	11,349.77	11,819.27	12,015.33	11,961.80	11,888.99	12,006.71	11,867.32	11,851.48	11,324.53	10,636.89	139,376.20
Total cost operation	56,211.06	56,899.75	54,363.56	58,954.73	59,484.92	61,547.31	61,403.55	57,419.25	60,621.21	59,187.51	58,485.99	56,725.23	701.304.07
Revenue:													
Coupons	53,202.30	52,476.00	50,736.00	54,884.40	53,799.90	56,212.80	58,201.20	53,730.60	58,087.20	54,773.40	54,273.60	52,492.80	652,870.20
Cash	444.65	400.95	284.05	355.72	743.55	1,269.99	1,709.45	1,143.85	1,372.30	1,345.00	1,080.90	839.80	10,990.21
Civil administration	943.05	915.95	918.20	892.40	835.85	856.85	853.40	806.90	917.30	902.10	981.60	970.55	10,794.15
Sanitary	1.80	.60	1.80		4.47	6.36	2.22	2.18	73.05	79.06	51.43	62.48	285.45
Construction and engineering	49.20	117.00	681.60	152.70	249.20	148.50	109.30	83.10	108.30	217.85	110.40	149.70	2,176.85
Marine Corps				88.50	95.40	81.60	104.70	224.40	268.80	179.70	25.20		1,068.30
Young Men's Christian Association	1.76	.80	.20		1.40	29.00	63.40	53.60	67.82	77.00	69.16	45.20	409.28
Deduction tickets	213.50												213.50

P. R. R. Commissary	5.00			7.80	19.90	83.17	12.75	65.70		24.00	7.50	25.50	251.32
Bills					63.50							12.60	76.10
Total revenue	54,861.20	53,911.30	52,621.85	56,381.52	55,813.17	58,688.27	61,056.42	56,110.33	60,894.77	57,598.11	56,599.79	54,598.63	679,135.36
Profit									273.56				
Loss	1,349.86	2,988.45	1,741.71	2,573.21	3,671.75	2,859.04	347.13	1,308.92		1,589.40	1,886.20	2,126.60	22,168.71
Meals served	176,530	174,180	170,426	184,462	178,885	188,605	195,772	178,925	193,963	183,273	179,029	172,401	2,176,451
Cost supplies per meal	$24.62	$25.37	$24.48	$24.80	$26.90	$25.48	$24.42	$24.38	$24.13	$24.81	$25.12	$24.91	$24.87
Cost service per meal	6.36	6.40	6.55	6.30	6.50	6.17	5.88	6.47	5.87	6.23	6.10	5.94	6.23
Total cost per meal	30.98	31.77	31.03	31.10	33.40	31.65	30.30	30.85	30.00	31.04	31.22	30.85	31.10

TABLE 4.—*Operations, European laborers' messes, July 1, 1909, to June 30, 1910.*

	1909.						1910.						
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total.
Inventories and in transit	$4,316.85	$3,447.05	$1,942.10	$1,831.31	$1,748.63	$2,142.10	$2,158.75	$2,091.26	$2,043.55	$2,192.84	$2,001.84	$2,138.17	$28,054.45
Purchases	20,703.55	7,316.06	7,215.90	7,841.67	7,305.15	7,870.84	9,286.87	8,746.93	9,588.38	8,656.93	9,672.80	8,249.55	112,454.63
Transfers	15,252.73	20,465.19	20,016.77	22,875.79	22,651.03	24,563.90	23,567.81	21,908.66	26,120.44	24,649.49	23,717.52	23,167.53	268,956.86
Discounts	980.02	356.86	347.48	379.40	367.13	390.23	456.74	427.67	616.96	526.85	589.18	411.95	5,850.47
Total to account for	41,253.15	31,585.16	29,522.25	32,928.17	32,071.94	34,967.07	35,470.17	33,174.52	38,369.33	36,026.11	35,981.34	33,967.20	415,316.41
Supplies transferred	11,894.31	3,968.32	2,957.74	3,511.30	3,126.75	3,333.68	2,931.49	2,636.95	2,730.24	2,541.67	2,404.18	2,476.55	44,513.18
Cleaning	153.56	156.95	150.01	168.68	174.01	181.35	186.49	202.70	221.77	246.33	244.78	245.03	2,331.66
Discounts allowed	980.02	1,054.65	1,049.88	1,067.97	1,101.07	1,169.87	1,162.22	981.67	1,446.11	1,280.32	1,041.71	742.48	13,077.97
Credit notes	12.40	27.29	21.97	13.49	80.75	5.61	40.68	43.29		4.51	3.63	38.24	291.86
Pay-roll deductions		7.60	4.96		11.39		1.87	2.15	1.22			.96	30.15
Inventories and in transit	3,447.05	1,942.10	1,831.31	1,748.63	2,142.10	2,158.75	2,091.26	2,043.55	2,192.84	2,001.84	2,138.17	1,591.87	25,329.47
Total issues	16,487.34	7,156.91	6,015.87	6,510.07	6,636.07	6,849.26	6,414.01	5,910.31	6,592.18	6,074.67	5,832.47	5,095.13	85.574.29
Supplies consumed	24,765.81	24,428.25	23,506.38	26,418.10	25,435.87	28,117.81	29,056.16	27,264.21	31,777.15	29,951.44	30,148.87	28,872.07	329,742.12
Expenses:													
Permanent equipment	149.54	213.16	48.48	68.62	213.60	375.99	161.68	53.53	483.86	161.91	268.29	186.79	2,385.45
Incidental equipment	22.23	127.91	110.82	74.97	122.71	89.21	135.38	103.62	82.83	152.04	96.11	121.02	1,238.85
Pay roll—													
Office and general	1,026.83	986.75	987.17	1,010.60	1,086.33	1,167.91	1,001.11	1,104.77	1,094.50	1,288.09	922.98	977.25	12,654.29
Mess	3,391.83	3,311.53	3,186.09	3,329.78	3,081.12	3,241.79	3,402.64	3,429.75	3,348.21	3,259.38	3,350.81	3,497.90	39,830.83
Transportation and utility	507.64	511.13	502.36	509.90	541.63	568.25	550.29	597.55	637.25	643.20	641.43	353.09	6,563.72
Coal	414.14	445.81	433.67	451.35	462.85	491.67	478.26	512.05	549.65	560.93	559.38	416.54	5,776.30
Laundry	20.17	15.83	21.20	21.94	28.36	51.72	42.97	60.09	103.95	43.67	35.25	35.51	480.66
Cleaning	153.56	156.95	150.01	168.68	174.01	181.35	186.49	202.70	221.77	246.33	244.78	245.03	2,331.66
Electric light and power	93.00	122.60	3.00	131.40	131.40	252.00	127.80	127.80	127.80	127.80	127.80	117.60	1,490.00
Total expense	5,778.94	5,891.67	5,442.80	5,767.24	5,842.01	6,419.89	6,086.62	6,191.86	6,649.82	6,483.35	6,246.83	5,950.73	72,751.76
Total cost, operation	30,544.75	30,319.92	28,949.18	32,185.34	31,277.88	34,537.70	35,142.78	33,456.07	38,426.97	36,434.79	36,395.70	34,822.80	402,493.88
Revenue:													
Tickets	31,993.13	31,615.00	30,924.82	33,476.54	31,701.40	35,542.23	38,295.87	36,233.27	43,344.70	40,868.33	40,879.10	37,734.70	432,609.09
Civil administration					2.20							6.60	8.80
Sanitary	367.87	435.47	350.13	330.94	352.00	400.40	373.33	321.33	321.07	308.27	315.07	347.60	4,223.48
Construction and engineering							8.50					42.40	50.90
Personal bills				24.40						.93			25.33
Quartermaster					8.00								8.00

Third division, chief engineer							1.87	.80	.80	.53	6.27	10.00	20.27
Mess kits, Panama R. R.									45.00				45.00
Panama R. R.									3.87	4.00			7.87
Total revenue	32,361.00	32,050.47	31,274.95	33,831.88	32,063.60	35,942.63	38,679.57	36,555.40	43,715.44	41,182.06	41,200.44	38,141.30	436,998.74
Profit	1,816.25	1,730.55	2,325.77	1,646.54	785.72	1,404.93	3,536.79	3,099.33	5,288.47	4,747.27	4,804.74	3,318.50	34,504.86
Rations served......number	80,899	80,332	78,186	84,506	80,134	89,856	96,701	91,390	109,176	102,952	103,001	95,354	1,092,487
Cost of supplies per ration	$30.61	$31.67	$30.00	$31.00	$31.70	$31.29	$30.05	$29.83	$29.11	$29.09	$29.27	$30.28	$30.18
Cost of service per ration	7.14	7.32	6.90	7.00	7.30	7.14	6.29	6.77	6.05	6.30	6.07	6.23	6.66
Total cost per ration	37.75	38.99	36.90	38.00	39.00	38.43	36.34	36.60	35.16	35.39	35.34	36.51	36.84

TABLE 5.—*Operations, common laborers' kitchens, July 1, 1909, to June 30, 1910.*

	1909.						1910.						Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	
Purchases	$1,785.05	$1,812.71	$1,362.36	$1,114.62	$1,116.02	$1,393.19	$2,168.45	$2,113.34	$2,129.76	$2,755.93	$1,741.02	$1,713.82	$21,206.27
Transfers	18,943.93	16,772.77	19,958.56	16,382.68	13,647.66	12,730.85	11,679.19	9,887.26	9,913.76	8,886.86	8,985.19	8,401.83	156,190.54
Discounts	92.04	95.97	72.21	58.37	59.11	71.48	113.53	108.60	142.22	173.86	111.13	90.20	1,188.72
Total to account for	20,821.02	18,681.45	21,393.13	17,555.67	14,822.79	14,195.52	13,961.17	12,109.20	12,185.74	11,816.65	10,837.34	10,205.85	178,585.53
Supplies transferred		11.63	32.42	38.99	35.38	104.78		15.38					238.58
Cleaning	83.65	72.23	70.97	72.53	74.31	71.91	61.14	66.03	77.11	83.46	93.39	71.13	897.86
Credit notes										5.64			5.64
Pay-roll deductions	.92			.96	.46	1.69	.43						4.46
Inventories and in transit										312.76			312.76
Total issues	84.57	83.86	103.39	112.48	110.15	178.38	61.57	81.41	77.11	401.86	93.39	71.13	1,459.30
Supplies consumed	20,736.45	18,597.59	21,289.74	17,443.19	14,712.64	14,017.14	13,899.60	12,027.79	12,108.63	11,414.79	10,743.95	10,134.72	177,126.23
Expenses:													
Permanent equipment	109.77	158.82	15.64	32.17	64.35	102.32	71.92	46.26	114.79	13.27	61.64	114.79	905.74
Incidental equipment	32.39	26.55	56.07	21.01	32.42	86.12	40.99	29.78	85.09	63.90	18.06	19.74	512.12
Pay roll—													
Office and general	851.15	767.63	916.60	734.40	643.96	613.65	526.53	506.46	413.98	482.01	333.63	344.58	7,134.58
Kitchen	2,043.06	1,922.75	2,029.28	1,797.92	1,579.63	1,569.66	1,609.46	1,484.09	1,352.59	1,428.61	1,353.70	1,227.93	19,398.68
Transportation and utility	402.91	398.85	452.87	376.30	294.16	282.70	263.02	235.68	215.67	240.69	231.82	111.10	3,505.77
Coal	348.19	347.86	402.70	330.18	277.16	258.34	251.55	234.72	216.70	209.90	202.20	146.87	3,226.37
Laundry	28.17	26.01	30.20	29.29	21.69	25.95	26.17	28.83	42.29	14.51	14.30	15.87	303.28
Cleaning	83.65	72.23	70.97	72.53	74.31	71.91	61.14	66.03	77.11	83.46	93.39	71.13	897.86
Electric light and power	20.65	45.00	2.25	24.45	24.45	46.50	23.25	23.25	23.25	23.25	23.25	21.80	301.35
Total expense	3,919.94	3,765.70	3,976.58	3,418.25	3,012.13	3,057.15	2,874.03	2,655.10	2,541.47	2,559.60	2,331.99	2,073.81	36,185.75
Total cost of operation	24,656.39	22,363.29	25,266.32	20,861.44	17,724.77	17,074.29	16,773.63	14,682.89	14,650.10	13,974.39	13,075.94	12,208.53	213,311.98
Revenue:													
Tickets	25,560.10	22,632.95	27,677.85	21,666.55	17,329.90	16,528.40	17,334.00	14,868.60	14,879.80	13,939.60	12,846.00	11,920.20	217,183.95
Civil administration	1,223.80	1,107.00	1,161.30	1,255.40	1,175.10	1,335.40	1,349.10	1,172.90	1,560.30	1,566.65	1,586.20	1,425.15	15,918.30
Sanitary	81.60	101.30	58.50	79.30	69.30	83.00	82.90	78.40	63.10	79.10	76.00	89.40	941.90
Construction and engineering									24.20	11.70			35.90
Panama R. R	3.00				44.85	66.85	15.60		67.10				197.40
Quartermaster					16.40						.30		16.70

Third division, chief engineer	....	....	....	....	....	....	63.00	32.20	35.10	17.70	18.00	12.20	178.20
Mess kits	....	....	....	....	....	....	....	....	....	6.60	33.30	11.70	51.60
Total revenue	26,868.50	23,841.25	28,897.65	23,001.25	18,635.55	18,013.65	18,844.60	16,152.10	16,629.60	15,621.35	14,559.80	13,458.65	234,523.95
Profit	2,212.11	1,477.96	3,631.33	2,139.81	910.78	939.36	2,070.97	1,469.21	1,979.50	1,646.96	1,483.86	1,250.12	21,211.97
Rations served	89,525	79,470	96,327	76,025	62,118	60,045	62,817	53,841	55,432	52,071	48,533	44,888	781,746
Cost supplies per ration	$23.16	$23.41	$22.10	$22.90	$23.70	$23.34	$22.13	$22.34	$21.84	$21.92	$22.14	$22.58	$22.66
Cost service per ration	4.38	4.73	4.10	4.40	4.80	5.01	4.56	4.93	4.59	4.92	4.80	4.62	4.63
Total cost per ration	27.54	28.14	26.20	27.30	28.50	28.35	26.69	27.27	26.43	26.84	26.94	27.20	27.29

APPENDIX M.

REPORT OF W. W. WARWICK, EXAMINER OF ACCOUNTS.

ISTHMIAN CANAL COMMISSION,
Empire, Canal Zone, August 8, 1910.

SIR: I have the honor to submit the following report of the business of the department of examination of accounts of the Isthmian Canal Commission, including the work done as auditor of the Canal Zone government, for the fiscal year ended June 30, 1910.

The outline of the work performed in the department, as contained in my last annual report, represents accurately the classes of work performed during the fiscal year 1910. No arrangement of the office work by divisions is made on a permanent plan, but the entire office force is used interchangeably on the different classes of work. At no time during the year have there been any employees not continually engaged in necessary work. Practically all of those in the office are required to be familiar to some extent with pay-roll work, in order that during the first eight days of each month a large force can be employed in making a careful audit of the pay rolls, while other work not so urgent can be laid aside for a few days. In this way no force is exclusively engaged on pay-roll work except such as is required on that work during every day of the month.

In the work of bookkeeping, the classification of expenditures, and the compilation of statistics some improvements have been made. The new plan of classified expenditures put into operation at the beginning of the year has improved the form of showing the expenditures of the commission. In accordance with your instructions, the expenditures from the beginning of the work were reclassified, as shown in Appendix 1, Exhibit C, in accordance with this new plan. A distribution of the accumulated plant charges, theretofore carried as one item, was made. The plant is now shown in the expenditure accounts by divisions and by units of the work. A method of absorbing the plant cost in canal-construction cost was also put into effect at the beginning of the year. In my last report the fact that about 800 bills a month were rendered against employees and other individuals and corporations was referred to. By a system of deduction slips the number of bills against employees has been largely reduced and the collections for sanitary work done in Panama and Colon for private persons have been made without bills. The number of bills has been reduced to an average of 450 a month. During the year the collection of all bills has received careful attention, and the amount uncollected is very much less than in former years. The accounting work in connection with collections from employees is seen to be of considerable volume, when it is noticed that practically all of more than 30,000 employees draw every month

commissary books or meal tickets, or both, that many employees on the gold rolls draw hotel books, and all classes of employees have miscellaneous deductions, such as payment of bond premiums, hospital service for their families, lost metal checks, etc An account must be kept and stated each month with all bonded employees making collections of money for the commission and with those charged with the issue of coupon books and meal tickets direct to employees. The accounts against the Panama Railroad Company for services rendered and material furnished by the commission are in a satisfactory condition. The officers of that company continue to cooperate in having such accounts paid promptly on presentation.

Claims and vouchers were presented for payment by the commission to the number of 3,706, aggregating nearly $10,000,000. This large amount includes, of course, the vouchers paid to the Panama Railroad Company on account of commissary coupon books sold by the commission to its employees, paid by deductions from their pay, and honored at the commissaries operated by the railroad company. At the close of the year the unpaid claims that had been presented by the Panama Railroad against the commission amounted to $276,000, of which $254,000 represented claims which were paid immediately after July 1, when new appropriations became available. The work in connection with claims and vouchers involved a larger number and a larger aggregate amount than last year, but was performed by the same force of employees. This was due to the fact that it has been possible to make the requirements as to government vouchers better known to all divisions on the Isthmus, and less correspondence and explanation was required. In addition to the voucher work, 372 claims were examined on account of unpaid salaries and wages due deceased employees. Of these claims, 300 involved the payment of money either to administrators or heirs or to consuls of foreign countries as the representatives of deceased alien employees. A considerable amount of salaries and wages of employees is not paid during the month succeeding that in which the money is earned. This is due to the absence of employees on account of sickness, or for other reasons. When the paid pay rolls are sent to this office by the disbursing officer, an accurate record of unpaid salaries and wages on such rolls is made and subsequent pay rolls are checked from this record. This work is kept current and it is believed prevents the possibility of duplicate or incorrect payments on account of services rendered at periods long distant from the time of payment.

Under the present system of auditing all classes of claims and accounts prior to their payment by the disbursing officer the administrative examination of his account after payment and before its transmission to the Auditor for the War Department does not require much time. The legality and correctness of all pay rolls and vouchers having been passed on by this office before approval by the chairman or heads of departments, it is only necessary to see that the disbursing officer has secured the proper receipts and presents the necessary evidence of actual payment.

An important work is that of inspecting accounts of bonded employees at all places on the Isthmus, and witnessing the transfer of responsibility from one bonded employee to another. Four in-

spectors have been engaged on this work and accomplished a total of 1,624 inspections; being 531 of cash accounts, 410 of coupon-book accounts, and 683 of meal-ticket accounts. The number of accounts subject to inspection was 128 cash accounts, 40 coupon-book accounts, and 67 meal-ticket accounts. It is the practice to have cash accounts inspected and verified at irregular times during the year and an average of four or five times for each account is considered sufficient, unless there is reason to believe that any particular account is being incorrectly kept. The coupon book and meal ticket accounts are inspected and verified about once a month in the offices of the timekeepers and others issuing such books and tickets. In these accounts an improvement has been made over former years, so that in the hundreds of thousands of coupon books and meal tickets issued the discrepancies due to errors have been reduced to a remarkably small number. There have been no defalcations during the year. It is believed this inspection work is an important factor, not only in preventing intentional wrongdoing, but also in reducing to a minimum the errors that can not be entirely prevented in the handling of such a large business.

The work of auditing the pay rolls was continued on the same plans as in the past year. There are now made on the Isthmus 118 pay rolls, carrying an aggregate of about 36,000 employees, of which about 4,000 names are duplicates due to service in more than one place. In addition to the auditing of all rolls during the first ten days of each month, and the keeping up of the personnel records from which the rolls are checked, a force of 12 men has been engaged, after the 10th of each month, in inspecting the timekeeping in all timekeeping offices on the Isthmus to verify the accuracy of the pay rolls sent in. This is done by checking the time rolls from the daily time books, and an examination is made to see that the pay rolls contain only the amount of time shown on the time rolls. The time given on the time rolls on account of sickness, court attendance, etc., is verified from the certificates attached to such rolls. This inspection of timekeeping offices completes the verification of the amount of pay given to each employee of the commission, because the time inspection force in the field checks, from day to day, the accuracy of the daily time books by a count of the men employed at the time of each inspection. In addition to the routine work in connection with pay rolls, there has been a number of compilations made under your instructions, to ascertain whether all departments were complying with the regulations concerning rates of pay for particular positions. Some of these statements involved all employees on the rolls and represented considerable extra work. There have also been made some comparative statements with reference to rates of pay in the different construction divisions. This work has tended to secure uniformity of pay on the Isthmus and to bring about a reduction in expense by requiring all departments to keep within the maximum rates established for the various positions. Comparative statements were made to show the errors detected in the audit of pay rolls from all divisions, and copies furnished each division.

The financial accounts with European contract laborers have been maintained and the records of a large number of such laborers have been verified and certificates issued, as well as certificates indicating payment in full for transportation. It has been the rule, since

Spanish laborers were first brought to the Isthmus under contract, to allow them to have employment at 20 cents an hour, at such times as they wish. The result has been that some have been away from the Isthmus for many months at a time. This required a verification of their records when again applying for work. The transfer from one laborer to another of the contract metal check has not been entirely prevented, but with the records now maintained it is more difficult to make the transfer without detection. More than $11,000 of excess pay have been recovered during the year from imposters holding contract checks. There is a considerable amount due the commission as reimbursement for transportation paid steamship companies on account of contract laborers, some of which is carried in the account of unpaid salaries and wages. A check of all unpaid pay receipts is being made for the purpose of applying to the outstanding balance any of such unpaid amounts as may be due contract laborers who have not completed payment to the commission for their passage.

Some work has been occasioned by the act of Congress of August 5, 1909, prohibiting the payment from public funds of the premium on the bond of any employee. Before that date the commission had been paying the premiums on the bonds of more than 300 employees, such as clerks, timekeepers, postmasters, postal clerks, storekeepers, quartermasters, and clerks of courts. The Comptroller of the Treasury decided that the law applied to the bonds of employees of the commission. Pending his decisions of September 8 and October 9 on the points involved, the National Surety Company was not paid the premiums for the year beginning July 1. That company thereupon gave sixty days' notice of its withdrawal from the bond. This notice was accepted and through the Washington office of the commission a new schedule bond, effective November 1, was obtained from the Illinois Surety Company, at a premium of $3 per thousand, instead of $4 per thousand previously paid. Each employee is now required to pay the premium on the amount for which he is covered in the schedule bond, which amount is from $1,000 to $20,000. In view of the fact that the bonding of all employees on the Isthmus (except disbursing officers) is not required by law but only by the regulations of the commission, it seems to me that the conditions are so exceptional as to justify the payment of these premiums from public funds. I therefore recommend that in the estimates for the fiscal year 1912 a clause be inserted to accomplish this purpose.

For convenience in carrying on the work of time inspection, the Isthmus was divided into five instead of four districts, with senior inspectors located at Ancon, Empire, Gorgona, Gatun, and Cristobal. The fifth district was created by making the territory around Gatun a separate district, owing to the fact that the force there had increased to over 6,000 employees, working in two or three shifts. The number of time inspectors was increased from 41 to 46. In addition to the ordinary daily work, such inspections at night and on Sundays were made at particular points as were found advisable. During the unusually heavy rains in November and December some difficulty was experienced in enforcing the rules concerning loss of time by hourly employees who were unable to work. Some special work has been done in the taking of inventories and investigating particular subjects under your instructions. The average number of men

inspected by each inspector per day ranges from 325 to 430, depending upon the locality and somewhat upon the weather. As a rule, all gangs employed on an hourly basis are inspected three or four times a week, and some of them practically every day. It is the rule to have the inspectors, as far as possible, secure the correction of irregularities in the field through the local superintendent or other official in charge. In addition to this, there were 2,483 special reports sent to and handled by this office with the departments and divisions concerned. These reports covered many subjects, such as location of abandoned property, misuse of property, coupon books, and transportation, erroneous ratings of employees, involving higher rates of pay than provided by the regulations, incorrect timing of employees, time lost on account of rain, buying and selling contract checks.

The work of these time inspectors in the field was difficult and of a nature that does not tend to make an inspector popular. Almost without exception the men employed have been industrious and faithful in the performance of duty, reporting irregularities when required to do so by the rules. These inspectors are used only in connection with the inspection of the working force during working hours, and do not report as to the conduct of employees at other times. The fact that it was necessary to employ in this work 42 new men during the year indicates that the work is neither easy nor popular, and that it requires the service of those who can stand outdoor work for long hours and the physical exertion of walking 10 or 15 miles a day. Some men have left the department in order to obtain better paying or easier positions in other branches of the service on the Isthmus. This loss can not be avoided, and it is believed that the work will continue to be well done with an entrance salary of $100 per month, as at present. An examination of the records indicates that this system of inspection results in the direct saving of a considerable amount of money. The almost complete absence of fraudulent attempts to pad the rolls or give men more time than they are entitled to receive indicates that the maintenance of this service is essential when the total payments for salaries and wages amount to almost $20,000,000 a year, in addition to the amounts paid by the Panama Railroad Company.

The duty of counting the cash in the hands of the disbursing officer has been performed and a count made twice during the year. In addition to this verification, the disbursing officer turned over all his cash to his assistant when he went on leave of absence and received the cash on hand on his return. The money in the hands of the treasurer of the Canal Zone was also verified from time to time.

The work in connection with the settlement of claims of employees on account of personal injuries has largely increased. The amount paid out on account of such injuries was $96,810.33, and on account of death claims was $21,053.22. There was also paid, on account of "meritorious sick leave," the sum of $16,010.30. Such sick leave represents small accidents which incapacitate employees for fifteen days or less. It is paid under authority of the act of February 24, 1909, as the general compensation act of May 30, 1908, provides only for injuries causing a loss of more than fifteen days. The number of accidents reported was 2,641. The time required to send claims to Washington for submission to the Secretary of Commerce and Labor has been somewhat reduced. Formerly it took from two to three

months, while recently the majority of cases have been returned to the Isthmus within four to six weeks. About 98 per cent of the claims submitted to the Secretary of Commerce and Labor have been approved. During the year a separate pay roll was established for the payment of compensation to injured employees. The roll is made up twice each month, and in case the disability of an employee continues for a year or the greater part of a year, payment is made once a month. Claims on account of the death of employees are approved for one year, and payments are made to the beneficiaries in monthly installments. Further details with reference to personal injuries and death, and the payment of compensation therefor, is given in the attached statements, marked Appendix 6 and Appendix 7.

In my last annual report I recommended that Congress be asked to authorize some officer on the Isthmus, preferably the chairman of the Isthmian Canal Commission, to pass upon claims of employees for compensation on account of injuries. I renew that recommendation as the change would tend to economy and the prompt payment of injured employees. As the average time covered by each claim for compensation is forty-four days and the commission now has authority, under the act of February 24, 1909, to allow not exceeding thirty days in cases of injury, it is my opinion that during the construction of the canal the subject could be properly intrusted to the commission, instead of requiring that each claim shall be sent, after the preparation of the number of papers now necessary, to Washington for action. In the last session of Congress a bill (H. R. 12316) passed the House of Representatives and was favorably reported by the Senate committee, which embodied in section 8 a plan by which the President would be authorized to prescribe the method of settling claims for injuries arising in the work of constructing the canal and operating the Panama Railroad. From the report of the House committee, it seemed to be the view that under existing law the amount of compensation allowed, particularly in the case of death or permanent injury, was not sufficient in the case of employees on the Isthmus. The Secretary of Commerce and Labor has discussed with the several departments of the Government the question whether the act of May 30, 1908, should not be so amended as to provide for more liberal compensation in the case of permanent injury or death of any government employee covered by that act. In any event, if the manner of settling claims is not changed and if the maximum amount—one year's pay—is not increased, it seems to me it would only be fair to canal employees if the restriction in the act of May 30, 1908, were removed so that the act would apply to others than artisans and laborers engaged in hazardous employment. This would allow superintendents, general foremen, and others to receive the benefits of the act. I think the Department of Commerce and Labor has been liberal in construing the law in favor of employees, in accordance with the view that it is a beneficial statute and should be liberally construed.

ACCOUNTS OF THE CANAL ZONE GOVERNMENT.

The attached statements, Appendixes 8, 9, 10, 11, and 12, show the revenues and expenditures of funds of the Canal Zone, together with the balances remaining at the close of the year. The detail

of the money-order business (Appendixes 10, 11, and 12) shows that there has been an increase in the value of money orders issued. To some extent the Canal Zone post-offices are used by employees as a place of deposit for savings. The act of Congress of June 25, 1910, to establish postal savings depositories in the United States, does not include the Canal Zone. It is respectfully suggested that American employees who are engaged in canal construction should have the benefit of a similar system of depositories, so that instead of paying a fee to deposit their savings in the post-offices they will receive interest thereon. Such a system could be established in the Canal Zone without the expense that is required in the United States; and it is recommended that request be made for an executive order establishing such a system, to continue, at least, until the completion of the canal. The interest that could be secured from banks would produce a surplus, after paying interest to depositors, sufficient to pay all of the expenses incurred in the operation of the system.

In section 3 of the act of June 25, 1910, Congress made such a change in the former law as permits the revenues and expenditures of the Canal Zone to be kept by fiscal years, beginning with July 1 of each year. No change was made in the law so as to authorize the use of balances remaining unexpended from the appropriations for each year. As will be seen by reference to Appendix 9, there are balances in the appropriations "Public improvements and schools" for 1908, 1909, and 1910, and balances for the same years in appropriations "Miscellaneous and contingent expenses." No one of these balances is available for use, unless it should be found that some expense for one of the fiscal years has not yet been paid. The balances for 1908 and 1909 will probably not be called on for any purpose, and will remain indefinitely without it being possible to make any use of them. In the estimates for the fiscal year 1911, this section relating to Canal Zone revenues was changed to make the funds available until expended, in the same manner that appropriations for canal construction are available. This was not acted upon favorably by Congress. In the case of appropriations made by Congress from funds in the Treasury of the United States, the law requires that, if such appropriations are made for the service of a particular fiscal year, the balance unused at the end of two fiscal years shall be covered into the Treasury, which action carries the money to the credit of the general fund—the unappropriated balance in the Treasury. This rule can not be adopted in the case of revenues of the Canal Zone, because Congress specifically appropriates in advance all revenues that may come in during a year from specific sources. There is, therefore, no general fund in the treasury of the Canal Zone to which unused balances can revert, and, if such balances of annual appropriations were carried to a general fund the money in the latter fund would not be available for use, nor would it be appropriated by existing law. Congress by each annual law appropriates only prospective revenues. In order to make these funds available, it is recommended that where the law now provides for "setting aside a miscellaneous and contingent fund of $10,000," it be changed to read "setting aside a miscellaneous and contingent fund of *not exceeding* $10,000." This would appropriate for miscellaneous and contingent expenses only such sum, not exceeding

$10,000, as is required and would prevent the accumulation of unused and unavailable balances in this fund. In order to make the balances in the appropriations for public improvements and schools available, it is suggested that after the words "the remaining revenues" there be inserted "including any balances unexpended in prior years."

During the year more than $1,000,000 was kept on deposit in a bank in the city of Washington to the credit of the treasurer of the Canal Zone. This represented, principally, money-order funds held pending settlement of the accounts with the United States Post-Office Department, and payment to that department when called for. Interest at 3½ per cent, to the amount of $36,867.94, was received on this deposit and credited, as a revenue of the Canal Zone, to the fund for public improvements and schools. During the latter part of the year a change in depositories was made by the Secretary of War, so that the deposit is now divided between two banks in the city of Washington.

The accounting system for the Canal Zone, established by your authority October 1, 1908, has operated successfully. All claims and accounts are settled by the auditor and transmitted to the treasurer for payment, without the employment of a disbursing officer. At the close of the fiscal year there were only 28 claims, amounting to $3,255.55, remaining unpaid. These were in course of examination. In the statement of balances in the Canal Zone treasury there is an item to the credit of postal receipts, 1910, of $11,136.79. A part of this will be used in payment of direct obligations and the balance transferred to the credit of the commission's appropriations, in part payment of the salaries of postal employees, and does not represent a surplus of postal receipts. The revenues from the postal service are not sufficient, after paying the Republic of Panama 40 per cent of the face value of stamps used, to maintain the service.

In addition to the ordinary work of auditing Canal Zone accounts, this office is charged with the duty of supervising and auditing the financial accounts of the club houses on the Isthmus—that is, the receipts and expenditures of the club houses, so far as they relate to the revenues derived from membership dues, sales of refreshments, operation of barber shops, billiard rooms, bowling alleys, etc., and the expenditure of these revenues in maintaining the work of the club houses for the benefit of employees. During the year some improvements have been made in the manner of accounting for these funds, especially in the way of having revenues paid into the treasury of the Canal Zone and the larger items of expense paid by check of the treasurer of the Canal Zone. The accounts of club houses are audited and inspected as are public accounts.

The authorized number of employees in this department was 127, at salaries aggregating $203,100. The actual expenditure for salaries was $187,301.76, a difference of $15,798.24. This was caused in part by delays in securing competent men to fill vacancies that occurred, but largely on account of the policy of not filling vacancies so long as it was possible to do the current work with the remaining force. The Panama Railroad Company pays $12,000 a year for time inspection work. The net cost to the commission for salaries in this department was, therefore, $175,301.76. While the total force employed was not as large as in the fiscal year 1909, an increase of 5 in the number of time inspectors was made, bringing the total of

that force up to 46. This was made necessary by the increase in the working force on the Isthmus, and the night and Sunday work at certain points. It is believed that by a continued effort to improve the methods of doing office work it will be possible to do the work of the department for less than the maximum amount authorized for the fiscal year 1911, and to make a reduction in the force by the close of the fiscal year 1911.

Respectfully,

W. W. Warwick,
Examiner of Accounts.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.

Appendix 1.—*Statement of receipts, disbursements, and balances available June 30, 1910.*

RECEIPTS.

Appropriations by Congress (Exhibit A)	$210,146,468.58
Water rentals, Panama and Colon	414,681.05
Collections account sale of government property, etc. (Exhibit B)	5,369,049.57
Collections due individuals and companies	15,048.92
Total receipts	215,945,248.12

DISBURSEMENTS.

Classified expenditures (Exhibit C)			191,258,113.93
Department of civil administration		$4,136,441.66	
Department of sanitation		11,476,580.23	
Hospital and asylums	$5,701,618.49		
Sanitation	4,731,793.72		
Construction and repair of buildings	1,043,168.02		
Department of construction and engineering		95,922,728.47	
Atlantic division	22,675,155.81		
Central division	58,240,248.14		
Pacific division	15,007,324.52		
General items		79,722,363.57	
General items	80,885,694.93		
Less value of French material sold or used in construction	1,163,331.36		
Paid into United States Treasury for sale of government property, etc			5,369,049.57
Services rendered and material sold individuals and companies			4,078,171.27
Unclassified expenditures			5,780,825.10
Material and supplies		5,525,773.33	
Other unclassified items		255,051.77	
Bills collectible outstanding			487,398.06
Total			206,973,557.93
Less amounts included in above but unpaid on June 30			1,828,003.39
Salaries and wages unpaid on rolls to June 1, 1910		214,356.83	
Pay rolls for the month of June, 1910		1,613,646.56	
Net disbursements			205,145,554.54
Balance available June 30, 1910			10,799,693.58
Congressional appropriations (Exhibit D)		10,681,194.75	
Miscellaneous receipts of United States funds		115,156.64	
Collections account of individuals and companies		3,342.19	
Due individuals and companies	15,048.92		
Less duty on scrap repaid appropriations and due to Panama Railroad Company	11,706.73		
Total			215,945,248.12

Note.—By an act of June 25, 1910, additional appropriations were made to continue the construction of the Isthmian Canal during the fiscal year 1911, available for expenditures July 1, 1910, as follows:

Expenses in the United States	$210,000.00
Construction and engineering	33,300,000.00
Civil administration	795,000.00
Sanitation and hospitals	1,550,000.00
Relocation of Panama Railroad	2,000,000.00
Total	37,855,000.00
Private act 97, June 17, 1910, relief of Elizabeth G. Martin	1,200.00

EXHIBIT A.—*Statement of appropriations by Congress.*

Purchase of canal rights, June 28, 1902		$40,000,000.00
Purchase of Canal Zone rights, April 28, 1904		10,000,000.00
Construction of canal:		
June 28, 1902		10,000,000.00
December 21, 1905		11,000,000.00
February 27, 1906		5,990,786.00
Construction of canal	$5,340,786.00	
Reequipment of Panama Railroad	650,000.00	
Construction of canal, June 30, 1906		25,456,415.08
Expenses in the United States	368,242.69	
Construction, engineering, and administration	21,018,537.24	
Civil administration	968,200.00	
Sanitation and hospitals	2,101,435.15	
Reequipment of Panama Railroad	1,000,000.00	
Construction of canal, March 4, 1907		27,161,367.50
Expenses in the United States	253,000.00	
Construction, engineering, and administration	20,366,000.00	
Civil administration	825,000.00	
Sanitation and hospitals	2,034,000.00	
Reequipment of Panama Railroad	1,385,000.00	
Purchase of Panama Railroad bonds	2,298,367.50	
Construction of canal, February 15, 1908		12,178,900.00
Expenses in the United States	18,600.00	
Construction, engineering, and administration	11,990,400.00	
Sanitation and hospitals	169,900.00	
Construction of canal, May 27, 1908		29,187,000.00
Expenses in the United States	176,000.00	
Construction, engineering, and administration	26,085,000.00	
Sanitation and hospitals	1,575,000.00	
Civil administration	241,000.00	
Reequipment of Panama Railroad	1,100,000.00	
Payment to P. B. Banton for injuries	10,000.00	
Construction of canal, March 4, 1909		5,458,000.00
Construction, engineering, and administration	5,458,000.00	
Construction of canal, March 4, 1909		33,638,000.00
Expenses in the United States	225,000.00	
Construction, engineering, and administration	29,368,000.00	
Civil administration	630,000.00	
Sanitation and hospitals	2,715,000.00	
Reequipment of Panama Railroad	700,000.00	
Construction of canal, February 25, 1910		76,000.00
Civil administration	76,000.00	
Total appropriations by Congress		210,146,468.58

EXHIBIT B.—*Detail of receipts for sale of property, services rendered, etc., which revert to the United States Treasury as miscellaneous receipts, to June 30, 1910.*

Sale of Isthmian Canal property		$1,085,463.03
Sale of property	$850,500.11	
Sale of French material and equipment	81,634.80	
Sale of water	255.43	
Sale of Panama Railroad stock	1,300.00	
Mess accounts	46,879.48	
Receipts from pay patients	79,992.68	
Quarantine subsistence	24,900.53	
Rental of Isthmian Canal property		534,441.02
Rent of lands and buildings	41,427.24	
Rent of equipment	311,047.33	
Panama water and sewer rentals	71,967.71	
Colon water and sewer rentals	31,573.00	
Rentals, miscellaneous	78,425.74	
Work done by Isthmian Canal Commission		207,786.52
Labor furnished Panama Railroad Company	180,336.97	
Other labor furnished	27,449.55	
Miscellaneous		2,790,164.00
Telegraph and telephone service	3,547.35	
Hotels and boarding camps	758,470.34	
Hotel coupon books	32,238.28	
Laundry receipts	7,382.01	
Corral receipts	8,628.56	
Miscellaneous	193,629.41	
Interest on loans	298,553.13	
Repayment of loans	1,487,714.92	
Subsidies and dividends		751,195.00
Annual subsidy from Panama Railroad Company	406,250.00	
Dividends on Panama Railroad stock	344,945.00	
Total		5,369,049.57

EXHIBIT C.—*Detailed statement of classified expenditures from the beginning of the work to June 30, 1910.*

Department of civil administration:	
Administration	$418,277.70
Supreme and circuit courts	266,464.28
Prosecuting attorney	27,240.08
Division of revenues	131,376.00
Division of posts	483,620.06
Division of customs	48,303.01
Division of lands and buildings	94,805.52
Division of estates	22,283.16
Police and prisons	1,363,198.87
Fire protection	444,834.80
Maintenance and operation waterworks and sewers—	
Panama	106,945.51
Colon	148,556.81
Repairs and maintenance of pavements—	
Panama	11,460.48
Colon	22,108.69
Miscellaneous Zone public works	18,870.41
Treasurer of the Canal Zone	19,243.89
Construction of buildings	502,228.38
Repairs to buildings	6,624.01
Total, department of civil administration	4,136,441.66
Department of sanitation:	
Administration	601,327.64
Hospitals and asylums—	
Medical storehouse, Colon	11,525.05
Ancon hospital	2,432,257.26
Colon hospital	1,318,039.14
Taboga sanitarium	35,716.14
Santo Tomas hospital	30,295.39
Other hospitals, dispensaries, and sick camps	1,472,900.42
Quarantine	246,919.31
Sanitation—Panama and Colon—	
Sanitation proper, Panama	685,392.46
Disposal of garbage, street cleaning, etc., Panama	48,887.52
Sanitation proper, Colon	530,942.84
Disposal of garbage, street cleaning, etc., Colon	11,251.35
Zone sanitation—	
Sanitation proper	2,796,970.04
Disposal of garbage, street cleaning, etc	210,987.65
Construction of buildings	1,011,022.43
Repairs to buildings	32,145.59
Total, department of sanitation	11,476,580.23
Department of construction and engineering:	
Atlantic division—	
Dry excavation (prism)—	
Construction work	1,002,250.14
Plant	50,614.80
Dredging excavation (prism)—	
Construction work	4,229,415.40
Plant	896,389.81
Gatun dam and spillway—	
Construction work	4,818,656.39
Plant	242,006.75
Gatun locks—	
Construction work	7,165,891.60
Plant	1,201,641.33
Gatun power plant (permanent)—	
Construction work	194,462.88
Rock and sand account—	
Porto Bello rock (plant)	818,305.55
Nombre de Dios sand (plant)	326,420.52
Transportation (plant)	1,165,885.34
Colon breakwater—	
Construction work	56,120.86
Plant	449,179.71
Gatun-Mindi levee	57,914.73
Total, Atlantic division	22,675,155.81
Central division—	
Dry excavation—	
Construction work	55,254,020.04
Plant	2,841,572.46
Dredging excavation—	
Construction work	9,798.40
Clearing channel in Gatun lake	134,857.24
Total, Central division	58,240,248.14

Department of construction and engineering—Continued.	
Pacific division—	
Dry excavation (prism)—	
Construction work	$211,150.55
Plant	279,108.22
Dredging excavation (prism)—	
Construction work	5,512,096.04
Plant	695,885.31
Pedro Miguel locks and dams—	
Construction work	2,627,255.34
Plant	619,233.40
Miraflores locks and dams—	
Construction work	2,889,364.00
Plant	686,071.65
Rock and sand account—	
Ancon rock plant	709,398.86
Chame sand plant	254,796.57
Miraflores power plant—	
Construction work	486,096.82
Naos Island breakwater—	
Construction work	36,867.76
Total, Pacific division	15,007,324.52
General items:	
Lands purchased—	
For construction work or to be flooded	252,802.70
For other purposes	73,210.35
Cristobal terminals—	
Docks and wharves	292,675.29
Dredging	10,417.80
Balboa terminals—	
Docks and wharves	191,121.16
Panama Railroad second main track	1,101,592.40
Relocation of Panama Railroad:	
Construction work	4,800,241.61
Maintenance	20,703.14
Plant	332,205.02
Purchase, improvement, and repair of steamers:	
Panama	*637,792.92*
Colon	*558,142.72*
Cristobal	*657,482.49*
Ancon	*667,173.97*
Construction of buildings, department of construction and engineering	9,503,208.16
Alteration and repair of buildings, department of construction and engineering	269,523.87
Purchase from New Panama Canal Company	40,000,000.00
Payment to Republic of Panama	10,000,000.00
Loans to Panama Railroad Company	3,347,332.11
Purchase of Panama Railroad stock	157,118.24
Construction waterworks and sewers:	
Panama	952,556.21
Colon	731,896.06
Zone waterworks and sewers:	
Construction	3,149,877.86
Repairs and maintenance	275,314.30
Paving:	
Panama	541,835.00
Colon	312,085.46
Zone roadways:	
Construction	1,394,404.98
Repairs and maintenance	61,249.26
Miscellaneous grading and other municipal work	3,419.29
Moving and care of French material and equipment	2,775.60
Plant in Panama Railroad service	587,536.96
Total, general items	80,885,694.93
Recapitulation:	
Department of civil administration	4,136,441.66
Department of sanitation	11,476,580.23
Department of construction and engineering—	
Atlantic division	22,675,155.81
Central division	58,240,248.14
Pacific division	15,007,324.52
General items	80,885,694.93
Grand total	192,421,445.29

EXHIBIT D.—*Statement of receipts and disbursements from appropriations for fiscal year ending June 30, 1910.*

	Balance brought forward July 1, 1909.	Appropriation Mar. 4, available July 1, 1909.	Deficiency appropriation Feb. 25, 1910.	Collections repaid to appropriations.	Total available during the year.	Disbursements.	Available balance June 30, 1910.
In the United States:							
Salaries	$28,064.79	$150,000.00		$2,773.28	$180,838.07	$147,759.48	$33,078.59
Incidentals	12,490.47	75,000.00		1,122.17	88,612.64	73,682.79	14,929.85
Construction and engineering:							
Officers and employees	940,756.23	3,871,000.00		73,686.29	4,885,442.52	3,635,558.82	1,249,883.70
Skilled and unskilled labor	1,854,869.21	12,000,000.00		1,628,027.41	15,482,896.62	13,133,123.34	2,349,773.28
Material and supplies	2,518,330.85	10,517,000.00		1,355,880.80	14,391,211.65	13,333,818.42	1,057,393.23
Incidental expenses	193,392.34	1,000,000.00		5,741.44	1,199,133.78	1,176,568.45	22,565.33
Civil administration:							
Officers and employees	51,318.21	470,000.00	$76,000.00	5.00	597,323.21	548,941.73	48,381.48
Skilled and unskilled labor	39,029.83	20,000.00			59,029.83	27,174.86	31,854.97
Material and expenses	173,575.20	140,000.00		563.40	314,138.60	141,726.84	172,411.76
Sanitation:							
Officers and employees	211,764.19	725,000.00		10,788.59	947,552.78	707,663.90	239,888.88
Skilled and unskilled labor	402,809.37	450,000.00		10,031.96	862,841.33	433,316.93	429,524.40
Material and expenses	124,954.33	740,000.00		75,507.28	940,461.61	674,648.58	265,813.03
Reequipment Panama R. R.	1,523,621.47	700,000.00			2,223,621.47	175,451.00	2,048,170.47
Relocation Panama R. R.	123,522.26	1,980,000.00		323.42	2,103,845.68	2,101,727.95	2,117.73
Canal connecting Atlantic and Pacific oceans	1,915,589.04			1,619.28	1,917,208.32	1,800.27	1,915,408.05
Sanitation in cities of Panama and Colon		800,000.00			800,000.00		800,000.00
Total	10,114,087.79	33,638,000.00	76,000.00	3,166,070.32	46,994,158.11	36,312,963.36	10,681,194.75

NOTE.—For detail of "Collections repaid to appropriations" see Exhibit E.

EXHIBIT E.—*Detailed statement of collections repaid to appropriations during the fiscal year ending June 30, 1910.*

Nature of collections.	From employees (act Mar. 4, 1907).	From other sources (act Mar. 4, 1910).	Total.
Sale of property	$17,653.67	$606,434.56	$624,088.23
Rent of equipment		123,532.26	123,532.26
Panama water rents		69,919.35	69,919.35
Colon water rents		71,399.45	71,399.45
Rentals, miscellaneous		33,112.73	33,112.73
Labor furnished Panama R. R		247,215.13	247,215.13
Other labor furnished	2,942.63	171,616.16	174,558.79
Sale of hotel books		70,754.42	70,754.42
Hotel and boarding camp receipts	1,349,227.36	43,781.01	1,393,008.37
Hospital receipts	84,174.88	51,793.26	135,968.14
Laundry receipts	9,578.51	1,734.40	11,312.91
Quarantine receipts	545.02	13,458.35	14,003.37
Corral service	14,609.54	28,512.57	43,122.11
Telegraph and telephone service	137.75	313.58	451.33
Transportation	4,371.57		4,371.57
Electric-light service	126.72	14,529.26	14,655.98
Sales of scrap		122,405.46	122,405.46
Duties on scrap refunded		11,706.73	11,706.73
Miscellaneous	29.96	322.01	351.97
Overpayments and corrections		132.02	132.02
Total	1,483,397.61	1,682,672.71	3,166,070.32

NOTE.—The first item includes in the $606,434.56 the amount of $142,200 paid by insurance companies to cover loss at sea of a dredge for which the contractor had been paid before delivery.

APPENDIX 2.—*Detailed statement of classified expenditures for fiscal year ending June 30, 1910.*

Department of civil administration:	
Administration	$50,189.74
Supreme and circuit courts	35,741.97
Prosecuting attorney	8,326.36
Division of revenues	9,837.56
Division of posts	80,965.29
Division of customs	10,087.56
Division of lands and buildings	4,726.63
Division of estates	1,975.59
Police and prisons	295,614.47
Fire protection	115,374.07
Maintenance and operation of waterworks and sewers—	
Panama	18,913.33
Colon	30,847.36
Repairs and maintenance of pavements—	
Panama	4,489.07
Colon	8,028.58
Miscellaneous Zone public works	8,313.04
Treasurer of the Canal Zone	11,207.59
Construction of buildings	8,089.15
Repairs to buildings	6,624.01
Total, department of civil administration	709,351.37
Department of sanitation:	
Administration	89,072.14
Hospitals and asylums—	
Medical storehouse, Colon	11,525.05
Ancon hospital	485,361.30
Colon hospital	172,307.14
Taboga sanitarium	33,507.07
Santo Tomas hospital	11,174.01
Other hospitals, dispensaries, and sick camps	239,235.30
Quarantine	43,961.97
Sanitation, Panama and Colon—	
Sanitation proper Panama	42,663.06
Disposal of garbage, street cleaning, etc., Panama	11,247.26
Sanitation proper, Colon	30,118.35
Disposal of garbage, street cleaning, etc., Colon	6,400.21
Zone sanitation—	
Sanitation proper	389,931.06
Disposal of garbage, street cleaning, etc	125,192.89
Construction of buildings	79,198.55
Repairs to buildings	32,145.59
Total, department of sanitation	1,803,040.95

Department of construction and engineering:	
Atlantic division—	
Dry excavation (prism)—	
Construction work	$226,901.91
Plant	a 24,461.07
Dredging excavation (prism)—	
Construction work	1,301,037.77
Plant	a 5,043.79
Gatun dam and spillway—	
Construction work	2,343,223.56
Plant	a 259,602.37
Gatun locks—	
Construction work	5,112,331.05
Plant	504,816.73
Rock and sand account—	
Porto Bello rock, plant	a 163,966.75
Nombre de Dios sand, plant	95,036.00
Transportation plant	35,828.19
Colon breakwater—	
Construction work	48,684.14
Plant	122,210.00
Gatun-Mindi levee	57,914.73
Total, Atlantic division	9,394,910.10
Central division—	
Dry excavation—	
Construction work	13,098,072.51
Plant	a 2,419,595.26
Clearing channel in Gatun Lake	134,857.24
Total, Central division	10,813,334.49
Pacific division—	
Dry excavation (prism)—	
Construction work	69,889.11
Plant	10,029.17
Dredging excavation (prism)—	
Construction work	1,806,986.47
Plant	a 41,215.26
Pedro Miguel locks and dams—	
Construction work	1,838,864.66
Plant	367,654.55
Miraflores locks and dams—	
Construction work	859,693.61
Plant	401,814.72
Rock and sand account—	
Ancon rock plant	381,484.71
Chame sand plant	92,691.05
Miraflores power plant—	
Construction work	267,161.91
Naos Island breakwater—	
Construction work	36,867.76
Total, Pacific division	6,091,922.46
General items:	
Lands purchased—	
For construction work or to be flooded	32,641.78
For other purposes	13,701.00
Cristobal terminals—	
Docks and wharves	a 56,773.30
Dredging	10,417.80
Balboa terminals—	
Docks and wharves	a 41,844.58
Panama Railroad second main track	6,317.50
Relocation of Panama Railroad—	
Construction work	2,067,571.68
Maintenance	20,703.14
Plant	44,053.61
Purchase, improvement, and repair of steamers—	
Panama	*a 13,700.80*
Colon	*a 61,074.87*
Cristobal	*51,841.43*
Ancon	*61,532.91*
Construction of buildings, department of construction and engineering	223,296.82
Alteration and repair of buildings, department of construction and engineering	269,523.87
Loans to Panama Railroad Company	a 662,263.92
Construction water works and sewers—	
Panama	94,391.21
Colon	125,141.08
Zone water works and sewers—	
Construction	294,587.84
Repairs and maintenance	275,314.30

a Credit.

General items—Continued.	
Paving—	
Panama	$40,359.68
Colon	1,875.14
Zone roadways—	
Construction	[a] 13,140.64
Repairs and maintenance	61,249.26
Miscellaneous grading and other municipal work	3,419.29
Moving and care of French material and equipment	2,775.60
Plant in Panama Railroad service	11,172.00
Total, general items	2,863,088.83

RECAPITULATION.

Department of civil administration	709,351.37
Department of sanitation	1,803,040.95
Department of construction and engineering:	
Atlantic division	9,394,910.10
Central division	10,813,334.49
Pacific division	6,091,922.46
General items	2,863,088.83
Grand total	31,675,648.20

[a] Credit.

APPENDIX 3.—*Statement of collections made on pay rolls of the Isthmian Canal Commission during the fiscal year ending June 30, 1910.*

GOLD ROLLS.

Month.	Total.	Commissary coupon books.	Hotel coupon books.	Subsistence.	Lost metal checks.	Transportation.	Medical service.	Bills collectible.	Miscellaneous.
1909.									
July	$141,429.35	$88,332.00	$49,480.13	$0.30	$26.50	$20.00	$221.00	$3,150.70	$198.72
August	142,396.51	89,188.33	49,760.41	3.30	24.00		202.00	1,820.64	1,397.83
September	145,023.70	92,162.45	49,309.20	2.15	26.50	20.00	206.00	1,637.37	1,600.03
October	150,524.32	96,305.20	50,846.28	2.15	21.50		808.55	1,012.10	1,528.54
November	157,144.31	101,077.21	51,704.40		19.50		1,480.53	457.85	2,404.82
December	164,636.52	109,583.99	51,244.73	3.25	29.00		2,048.49	136.32	1,590.74
1910.									
January	165,255.89	103,370.00	58,251.74	.80	28.00		1,537.08	328.55	1,739.72
February	156,114.68	102,096.33	50,095.40	2.10	28.00		1,887.84	409.46	1,595.55
March	159,430.91	103,558.61	51,825.94	16.30	26.00		2,121.89	351.32	1,530.85
April	162,467.89	107,324.25	50,838.77	6.97	31.50		2,222.99	333.88	1,709.53
May	157,149.22	103,655.84	49,580.85	4.30	26.50		1,963.75	264.35	1,653.63
June	156,296.27	102,718.13	49,328.28	5.10	27.50		2,423.22	150.81	1,643.23
Total	1,857,869.57	1,199,372.34	612,266.13	46.72	314.50	40.00	17,123.34	10,053.35	18,653.19

SILVER ROLLS.

Month.	Total.	Commissary coupon books.	Hotel coupon books.	Subsistence.	Lost metal checks.	Transportation.	Medical service.	Bills collectible.	Miscellaneous.
1909.									
July	$153,143.19	$95,914.95	$150.00	$55,915.53	$354.00	$321.45	$12.00	$137.73	$337.53
August	144,681.56	94,009.63	165.00	49,464.88	310.50	209.90	16.00	211.32	294.33
September	148,276.94	93,472.22	120.00	53,664.82	311.00	155.00	17.00	140.40	396.50
October	148,558.59	95,509.10	84.60	51,837.07	293.50	193.90	139.70	113.19	387.53
November	140,305.44	93,472.40	105.00	45,671.31	262.00	218.20	211.60	48.48	316.45
December	169,054.47	115,127.50	75.00	52,374.89	277.50	714.52	219.68	18.00	247.38
1910.									
January	158,890.43	107,542.43	64.80	49,907.19	308.00	457.30	242.06	37.70	330.95
February	157,592.52	107,141.45	109.80	48,947.00	286.00	347.03	401.56	168.85	190.83
March	170,562.39	114,306.50	105.00	54,679.29	303.00	405.17	301.46	113.95	348.02
April	172,762.06	118,754.37	90.00	52,414.75	254.00	482.25	307.07	31.20	428.42
May	165,428.88	116,252.23	75.00	47,557.68	260.50	408.40	459.30	115.60	300.17
June	171,320.48	123,382.74	75.00	45,925.96	288.50	560.40	788.94	13.80	285.14
Total	1,900,576.95	1,274,885.52	1,219.20	608,360.37	3,508.50	4,473.52	3,116.37	1,150.22	3,863.25
Grand total	3,758,446.52	2,474,257.86	613,485.33	608,407.09	3,823.00	4,513.52	20,239.71	11,203.57	22,516.44

Appendix 4.—*Statement of hotel coupons and meal tickets honored during the fiscal year ending June 30, 1910.*

Month.	Messes.		Kitchens.		Hotels.	
	40-cent tickets.	Value.	30-cent tickets.	Value.	30-cent tickets.	Value.
1909.						
July	78,691	$31,476.40	86,690	$26,007.00	181,798	$54,539.40
August	77,271	30,908.40	77,068	23,120.40	179,166	53,749.80
September	75,604	30,241.60	93,172	27,951.60	173,107	51,932.10
October	82,435	32,974.00	73,601	22,080.30	185,837	55,751.10
November	78,617	31,446.80	58,419	17,525.70	182,443	54,732.90
December	87,935	35,174.00	55,775	16,732.50	190,196	57,058.80
1910.						
January	94,653	37,861.20	59,097	17,729.10	197,153	59,145.90
February	89,626	35,850.40	50,581	15,174.30	181,711	54,513.30
March	107,297	42,918.80	50,713	15,213.90	196,377	58,913.10
April	101,213	40,485.20	47,407	14,222.10	185,272	55,581.60
May	101,473	40,589.20	43,872	13,161.60	183,191	54,957.30
June	93,772	37,508.80	40,568	12,170.40	176,813	53,043.90
Total	1,068,587	427,434.80	736,963	221,088.90	2,213,064	663,919.20

Appendix 5.—*Statement of Isthmian Canal Commission bills registered for collection during the fiscal year ending June 30, 1910.*

Month.	Number of bills.	Amount.
1909.		
July	923	$157,855.73
August	647	208,824.40
September	643	121,551.85
October	405	125,025.09
November	266	143,308.50
December	312	311,365.26
1910.		
January	337	106,690.75
February	308	104,483.20
March	358	84,882.01
April	395	110,073.45
May	311	90,502.21
June	311	154,499.10
Total	5,216	1,719,061.55

APPENDIX 6.—*Statement of injuries sustained by employees of the Isthmian Canal Commission, July 1, 1909, to June 30, 1910, for which compensation was due or claimed under acts of Congress of May 30, 1908, and February 24, 1909.*

	Department or division.											
	Central.	Atlantic.	Pacific.	Quartermaster.	Mechanical.	Sanitary.	Civil administration.	Subsistence.	Chief engineer.	Examiner of accounts.	Washington office.	Total.
Injuries reported	429	452	197	46	79	3	7	1	1	2	1	1,218
Claims for injuries:												
Filed	411	431	187	39	78	3	7	1	1	2	1	1,161
Approved	308	318	161	23	68	2	6	......	1	2	......	889
Disapproved	11	6	3	5	1	......	1	......	......	......	......	27
Accidental deaths reported	26	41	10	2	1	1	......	......	......	......	......	81
Death claims:												
Filed	4	25	6	1	1	1	......	......	......	......	......	38
Approved	3	10	5	......	......	......	......	......	......	......	......	18
Disapproved	......	3	......	......	......	1	......	......	......	......	......	4
Other claims for 15 days or less	475	427	178	111	141	4	6	......	......	......	......	1,342
Total accidents reported	930	920	385	159	221	8	13	1	1	2	1	2,641

Injury claims pending with the Department of Commerce and Labor, 113.
Death claims pending with the Department of Commerce and Labor, 10.
Average duration of disability of cases for which claims have been filed, 44 days.
All other cases less than 15 days estimated duration, 7 days.
Principal reasons assigned for disapproval of injury claims: Negligence; not in line of duty; nonhazardous employment; and no evidence of connection between accident and incapacity.
Principal reasons assigned for disapproval of death claims: Not filed within 90 days; and not dependent parent within meaning of act.

APPENDIX 7.—*Statement of amounts paid, under act of May 30, 1908, to employees as compensation and on account of death of employees, injured in course of employment, July 1, 1909, to June 30, 1910, and amounts paid, under act of February 24, 1909, for injuries lasting fifteen days or less.*

Department or division.		July.	August.	September.	October.	November.	December.	January	February.
Central	Injury	$5,761.93	$2,836.79	$2,317.03	$3,197.53	$2,100.66	$5,253.56	$4,023.02	$3,181.58
	Death	559.80	1,318.81	655.20	1,062.93	2,386.86	1,962.92	558.48	1,130.28
Atlantic	Injury	1,292.06	1,182.98	2,131.48	346.72	778.32	815.96	2,736.52	2,892.04
	Death	....	....	....	....	....	103.00	30.00	393.87
Pacific	Injury	1,263.43	702.12	825.42	615.79	1,192.69	1,319.71	1,489.55	888.02
	Death	....	....	....	....	....	366.21	....	77.40
Quartermaster	Injury	329.34	253.74	117.05	59.67	43.33	447.53	335.29	149.76
Mechanical	do	1,446.27	727.23	397.51	1,128.77	1,235.94	426.40	1,206.82	562.27
	Death	....	191.36	....	133.12	....	39.68	....	....
Sanitary	Injury	333.45	175.40	70.00	....	8.00	80.00	79.17	100.00
Civil administration	do	....	93.00	....	....	81.00	141.67	103.33	25.33
Chief engineer	do	....	....	....	....	29.25	....	....	....
Examiner of accounts	do	....	....	....	....	....	....	....	....
Total		10,986.28	7,481.43	6,513.69	6,544.53	7,856.05	10,956.64	10,562.18	9,400.55

Department or division.		March.	April.	May.	June.	Total injury payments.	Total death payments.	Total under act Feb. 24, 1909.	Grand total.
Central	Injury	$3,223.98	$3,658.96	$2,210.37	$2,563.61	$40,329.02	....	$5,720.68	$60,224.29
	Death	1,881.01	615.00	1,585.45	457.85	....	$14,174.59	....	....
Atlantic	Injury	2,241.94	2,737.60	2,574.09	4,017.28	23,746.99	....	4,988.57	32,238.02
	Death	852.90	419.61	684.75	1,018.33	....	3,502.46	....	....
Pacific	Injury	2,824.69	1,252.57	1,912.12	2,590.10	16,876.21	....	2,231.21	21,299.43
	Death	630.00	207.00	469.20	442.20	....	2,192.01	....	....
Quartermaster	Injury	92.21	172.10	109.66	207.55	2,317.23	....	1,040.20	3,357.43
Mechanical	do	1,012.31	982.62	996.74	1,582.56	11,705.44	....	1,801.19	14,690.79
	Death	....	....	244.00	576.00	....	1,184.16	....	....
Sanitary	Injury	50.00	19.17	....	....	915.19	....	186.28	1,101.47
Civil administration	do	79.17	....	....	....	523.50	....	42.17	565.67
Chief engineer	do	....	....	....	....	29.25	....	....	29.25
Examiner of accounts	Injury	....	255.00	112.50	....	367.50	....	....	367.50
Total		12,888.21	10,319.63	10,898.88	13,455.48	96,810.33	21,053.22	16,010.30	133,873.85

APPENDIX 8.—*Receipts and expenditures from July 1, 1909, to June 30, 1910.*

REVENUES COLLECTED.

[This statement includes balances in hands of collecting officers, but does not include money order, Y. M. C. A., nor trust funds.]

On account of—	Administrative district.				
	Ancon.	Empire.	Gorgona.	Cristobal.	Total.
Animal license	$71.40	$191.40	$119.70	$110.10	$492.60
Aerated waters	867.60	2,724.80	2,089.20	1,521.60	7,203.20
Auctioneers		24.00	7.00	4.00	35.00
Building rentals	2,660.00	1,872.00	463.35		4,995.35
Bowling alleys		65.00			65.00
Burial permits	314.75	314.75	314.75	314.75	1,259.00
Cabs and coaches		12.75	4.25	16.25	33.25
Carts	7.40	218.40	39.60	114.60	380.00
Circuit court collections	1,877.49	1,877.99	1,878.00	1,877.97	7,511.45
District court collections	8,811.50	8,725.05	5,422.59	7,340.55	30,299.69
Dance halls		130.00	70.00	90.00	290.00
Distilling license	682.81	597.14	1,242.38	636.34	3,158.67
Escheated estates	170.02	170.01	170.01	170.00	680.04
Gathering cocoanuts				105.00	105.00
Hucksters		10.80		104.00	114.80
Hunting permits	433.75	437.75	433.75	433.75	1,739.00
Insurance tax	58.58	58.58	58.59	58.59	234.34
Interest	9,216.99	9,216.99	9,216.98	9,216.98	36,867.94
Land rental	2,982.01	7,585.51	9,542.91	2,172.26	22,282.69
Maintenance miscellaneous public works (refund)	372.75	372.75	372.75	372.75	1,491.00
Market rental	384.00	2,566.30	902.25	604.00	4,456.55
Merchandise and drugs	1,124.20	4,163.55	3,125.41	1,309.10	9,722.26
Marshal's fees	164.49	164.50	164.53	164.53	658.05
Peddling	1,378.00	3,757.50	2,256.00	2,692.50	10,084.00
Physician's license	32.50	32.50	32.50	32.50	130.00
Public entertainment	41.50	512.20	157.70	103.50	814.90
Poll tax	244.40	774 40	403.60	312.40	1,734.80
Pound fees	77.50	213.20	123.20	122.20	536.10
Police fines	106.01	106.00	105.99	106.00	424.00
Restaurants	248.20	671.40	402.60	193.00	1,515.20
Retail liquor license		32,640.00	21,600.00	10,800.00	65,040.00
Retail sale of tobacco	849.60	3,736.80	2,532.40	1,965.20	9,084.00
Real estate tax	3,907.54	10,986.42	12,607.94	5,209.06	32,710.96
School tuition (lost or damaged books)	73.28	73.28	73.26	73.26	293.08
Services district prisoners	216.95	216.97	216.97	216.96	867.85
Sale of property	7.65	7.65	259.15	7.65	282.10
Sale impounded animals	3.75			9.50	13.25
Slaughter tax	145.00	10,997.50	4,005.00	348.50	15,496.00
Sale imported meats	355.45	103.17	2.95	83.64	545.21
Water tax	1,079.85	5,732.15	3,910.45	2,240.00	12,962.45
Total	38,966.92	112,061.16	84,327.71	51,252.99	286,608.78
Sale of postage stamps					83,847.10
Money order fees					22,957.35
Total					393,413.23

EXPENDITURES.

[This statement includes all outstanding audited claims, but does not include expenditures of money-order, Y. M. C. A., nor trust funds.]

On account of—	Administrative district.				
	Ancon.	Empire.	Gorgona.	Cristobal.	Total.
Public improvements.					
Roads and trails:					
Construction	$40,495.86	$46,618.53	$16,749.55	$87,139.72	$191,003.66
Maintenance	602.11	9,398.97	5,141.67	66.00	15,208.75
Market houses:					
Construction		125.85		2,371.48	2,497.33
Maintenance	12.68	279.25	278.07	116.77	686.77
Operation	454.88	454.89	482.90	469.91	1,862.58
Slaughterhouses:					
Construction		197.82			197.82
Maintenance	67.50	52.99	89.47	14.71	224.67
Operation	327.31	327.32	327.31	327.31	1,309.25
Waterworks and sewers:					
Construction	427.70	8,137.76	1,112.20	15,333.57	25,011.23
Maintenance		1,466.34	416.82	21.00	1,904.16
Maintenance and sanitation native villages	3,125.00	3,125.00	3,125.00	3,125.00	12,500.00
Street lighting	274.43	192.38	423.88	336.21	1,226.90
Miscellaneous public works:					
Construction	357.62	5,355.28			5,712.90
Maintenance	54.22	817.21	523.64	30.56	1,425.63
Public schools.					
Schoolhouses:					
Construction	20.32	4,154.45	1,466.04	7,236.26	12,877.07
Maintenance	191.03	1,530.57	608.37	485.02	2,814.99
Rental	150.00				150.00
Salaries superintendent, teachers, and clerks	12,859.17	12,859.20	12,859.23	12,859.22	51,436.82
Janitor service	405.46	806.27	567.59	783.66	2,562.98
Furniture and equipment	469.34	657.00	218.76	579.97	1,925.07
Supplies	1,096.87	1,436.59	984.75	1,396.95	4,915.16
Traveling and miscellaneous expenses	492.52	363.88	97.39	207.52	1,161.31
Maintenance, administrative districts.					
Salaries tax collectors	2,932.67	2,932.71	2,932.72	2,932.72	11,730.82
Salaries district judges	4,181.66	4,181.66	4,181.67	4,181.67	16,726.66
Supplies and miscellaneous	629.94	1,478.54	782.27	561.54	3,452.29
Equipment		5.10			5.10
Zone charity cases, maintenance	200.00	200.00	200.00	200.00	800.00
District prisoners, maintenance	3,831.40	4,432.90	5,258.00	1,962.70	15,485.00
Total	73,659.69	111,588.46	58,827.30	142,739.47	386,814.92
Contingent expenses.					
Gratuity, penitentiary prisoners					757.50
Miscellaneous					1,200.70
Postal service.					
Purchase of stamps					29,400.00
Transportation of mails:					
Isthmus					14,950.67
Ocean					17,419.28
Miscellaneous expenses					10,417.19
Transfer to Isthmian Canal Commission as reimbursement in part for salaries paid					35,000.00
Total					495,960.26

APPENDIX 9.—*Statement of balances in treasury, by appropriations, June 30, 1910.*

Public improvements and schools	$43.27
Fiscal year 1908	4,458.73
Fiscal year 1909	15.75
Fiscal year 1910	39,743.82
Miscellaneous and contingent	743.25
Fiscal year 1908	3,780.15
Fiscal year 1909	1,181.70
Fiscal year 1910	8,172.75
Postal service, fiscal year 1910	11,136.79
Money-order funds	1,325,051.73
Young Men's Christian Association funds	11,794.58
Trust funds	2,510.66
Invalidated money orders	6,227.32
Total	1,414,860.50

APPENDIX 10.—*Statement showing total value of money orders issued, money orders paid, money orders outstanding, and balance of money-order funds June 30, 1910.*

POSTAL SERVICE.

Year ending June 30—	Money orders issued on—			Total.
	United States.	Canal Zone.	Martinique.	
1907	$2,067,358.87	$301,672.62		$2,369,031.49
1908	3,460,755.25	1,225,929.73		4,686,684.98
1909	3,783,090.44	1,383,659.02		5,166,749.46
1910	3,976,883.08	1,247,610.22	$4,060.30	5,228,553.60
Total	13,288,087.64	4,158,871.59	4,060.30	17,451,019.53

Year ending June 30—	Money orders paid by—			Total.
	United States.	Canal Zone.	Martinique.	
1907	$1,581,251.91	$208,165.48		$1,789,417.39
1908	2,875,719.61	1,017,750.97		3,893,470.58
1909	3,583,419.57	1,492,144.76		5,075,564.33
1910	4,068,650.46	1,331,568.20	$2,267.60	5,402,486.26
Total	12,109,041.55	4,049,629.41	2,267.60	16,160,938.56

Money orders outstanding year ending June 30, 1910:		
Drawn on United States	$949,332.06	
Drawn on Canal Zone	339,063.21	
Drawn on Martinique	1,685.70	
		$1,290,080.97

SUMMARY.

Total money orders drawn—		
On the United States	$13,288,087.64	
On the Canal Zone	4,158,871.59	
On Martinique	4,060.30	
		$17,451,019.53
Total money orders paid—		
By the United States	12,109,041.55	
By the Canal Zone	4,049,629.41	
By Martinique	2,267.60	
Total outstanding—		
Drawn on the United States	949,332.06	
Drawn on the Canal Zone	339,063.21	
Drawn on Martinique	1,685.70	
		17,451,019.53
Money orders drawn on and paid—		
In the United States	12,109,041.55	
In Martinique	2,267.60	
		12,111,309.15
Money-order funds remitted—		
To the United States	11,877,000.00	
To Martinique	2,200.00	
United States orders paid in Canal Zone	164,793.23	
Due United States Post-Office Department	67,248.32	
Due Martinique post-office department	67.60	
		12,111,309.15

MONEY-ORDER FUNDS.

Cash in hands of treasurer, Canal Zone	$1,331,279.05	
Cash in hands of postmasters, Canal Zone	26,117.84	
		$1,357,396.89

APPENDIX 11.—*Statement of money-order business and stamp sales, fiscal year ended June 30, 1910.*

Name of office.	Amount issued.	Drawn on— United States.	Drawn on— Canal Zone.	Drawn on— Martinique.	Drawn on— United States, repaid in Canal Zone.	United States money orders paid in Canal Zone.	Drawn on United States, repaid in Martinique.	Issued and paid in Canal Zone.	Fees.	Stamp sales.
Ancon	$444,959.20	$382,984.53	$61,679.67	$295.00	$4,609.99	$9,627.48		$98,956.98	$2,126.41	$11,860.00 a 53.02
Balboa	270,450.89	185,428.24	84,950.05	72.60	3,026.47	1,737.86		75,695.34	1,110.87	3,135.60
Bas Obispo	141,774.92	98,095.09	43,600.83	79.00	2,009.00	978.51		37,968.72	611.62	2,007.00
Corozal	141,662.68	88,782.90	52,879.78		377.41	1,543.32		44,041.76	572.78	1,400.00
Cristobal	1,023,725.67	894,708.02	128,705.65	312.00	11,197.39	14,532.49		220,866.86	4,442.54	19,254.00 a 28.48
Culebra	379,337.83	285,361.20	93,449.13	527.50	6,631.39	3,701.68	$37.00	83,976.81	1,689.57	6,001.00
Empire	461,150.31	368,966.52	91,592.79	591.09	4,548.46	5,279.90	5.00	103,635.70	2,162.36	8,795.00
Gatun	609,110.20	462,735.04	146,160.16	215.00	6,182.31	7,389.92		108,045.47	2,787.83	10,055.00
Gorgona	510,739.75	363,727.20	146,095.85	916.70	10,189.73	3,240.87		119,192.04	2,152.10	5,545.00
Las Cascadas	286,135.58	204,129.67	81,899.91	106.00	5,895.24	1,250.72	60.00	75,300.42	1,165.16	3,045.00
Matachin	60,570.37	37,254.85	23,029.02	286.50	1,042.70	770.11		16,402.18	311.58	1,555.00
Miraflores	80,287.61	43,691.31	36,591.30	5.00	792.09	185.88		30,280.83	367.48	1,155.00
Paraiso	154,817.59	107,780.58	46,987.01	50.00	2,235.94	3,027.98		40,942.10	689.43	2,062.00
Pedro Miguel	370,496.56	249,196.84	120,912.72	387.00	4,045.99	2,210.36		111,885.28	1,535.62	3,380.00
San Pablo	110,416.66	68,839.94	41,405.72	171.00	2,862.95	2,521.88	5.00	40,777.02	466.65	1,302.00
Tabernilla	182,917.78	135,201.15	47,670.63	46.00	3,467.20	2,471.78		42,029.15	788.96	2,353.00
Bohio										718.00
District quartermaster, Mount Hope										143.00
Invalidated					2,748.25			9,599.12		
Total	5,228,553.60	3,976,883.08	1,247,610.22	4,060.30	71,865.42	60,470.77	107.00	1,259,595.78	22,980.96	83,847.10

a Newspaper postage.

APPENDIX 12.—*Statement of the money-order business of the Canal Zone postal service, fiscal year June 30, 1910.*

Month.	Orders issued.	Fees.	Drawn on—			Issued in United States; paid in Canal Zone.	Drawn on—		Issued and paid in Canal Zone.	Cash remittances to United States Post-Office Department.	Drawn on and paid in United States.
			United States.	Canal Zone.	Martinique.		United States; repaid.	Martinique; repaid.			
1909.											
July	$417,378.10	$1,790.08	$306,131.63	$111,246.47		$4,561.98	$7,664.98		$126,410.18	$255,000.00	$598,850.57
August	409,481.22	1,764.51	309,540.07	99,913.15	$28.00	4,265.80	5,150.13		105,892.54	325,000.00	355,880.48
September	417,803.50	1,826.17	311,734.23	105,795.77	273.50	5,558.75	5,262.69		110,268.98	245,000.00	385,505.77
October	431,421.47	1,871.50	323,721.09	107,386.88	313.50	4,033.44	7,534.07		85,530.31	315,000.00	335,973.14
November	442,296.91	1,979.07	344,723.61	97,199.80	373.50	4,784.26	4,873.63		83,902.87	295,000.00	316,679.32
December	460,311.98	2,088.66	368,612.65	91,212.83	486.50	4,883.02	5,620.43		105,609.97	315,000.00	343,263.51
1910.											
January	422,047.30	1,850.32	320,354.84	101,213.36	479.10	4,934.56	3,561.73	$15.00	86,245.85	325,000.00	339,988.09
February	427,841.02	1,894.56	330,957.93	96,423.09	460.00	4,400.39	6,695.39		83,688.84	285,000.00	340,787.37
March	481,505.67	2,136.18	366,095.81	114,827.36	582.50	4,166.39	5,143.42	37.00	106,327.70	300,000.00	413,231.35
April	456,369.10	2,011.45	348,882.97	107,140.63	345.50	6,027.52	5,706.76		124,593.98	345,000.00	296,225.00
May	439,011.39	1,907.31	329,893.32	108,743.07	375.00	5,373.87	6,338.10	51.00	114,620.35	280,000.00	342,265.86
June	423,085.94	1,861.15	316,234.93	106,507.81	343.20	7,480.79	8,314.09	4.00	126,504.21	250,000.00	
Total	5,228,553.60	22,980.96	3,976,883.08	1,247,610.22	4,060.30	60,470.77	71,865.42	107.00	1,259,595.78	3,535,000.00	4,068,650.46

APPENDIX N.

REPORT OF EDWARD J. WILLIAMS, DISBURSING OFFICER.

Isthmian Canal Commission,
Disbursing Department,
Empire, Canal Zone, July 30, 1910.

Sir: I have the honor to submit the following report of the disbursing department on the Isthmus for the fiscal year ended June 30, 1910:

On account of the subsidiary Panamanian coinage disappearing from circulation, it became necessary, in September, 1909, to cease paying out the 1, 5, 10, and 20 cent Panamanian pieces, except at the Ancon and Cristobal pay offices (contiguous to Panamanian territory), and substitute therefor, at Empire and on the pay car, for both gold and silver men, the United States coins.

In order to expedite payments, automatic cashiers were placed on the pay car for the payment of change where less than $1 is required in each individual case. This is a scheme which has been in use for a considerable number of years in the States and not only expedites the payment of these small coins, but insures correctness as well. This has proved quite advantageous and has resulted in increased satisfaction among the silver employees for the reason that they all much prefer United States money to the Panamanian silver.

The larger Panamanian coins, the peso and half peso, are at times scarce, tending to show that they are being hoarded or else that the amount coined is hardly sufficient for the needs of the public. Should any further scarcity develop I would recommend that the present silver pay rolls (so designated) be continued, but that United States money be paid to the entire force, as within a very short time sufficient gold would be accumulated on the Isthmus for that purpose.

The only shipment of money received from the United States during the past year was a quantity of United States change, made necessary on account of the scarcity of the smaller Panamanian coins.

Statement No. 1 attached shows the following information by months and grand total for the past fiscal year: Totals of gold rolls, silver rolls, and public bills, and reimbursement vouchers; also total number of payments made on the pay rolls for each month.

Statement No. 2 gives number and value of hotel and commissary books and meal tickets issued from this office to the various departments, by months, for the past fiscal year, a total valuation of $3,845,391.

Respectfully,

Edward J. Williams,
Disbursing Officer.

Col. Geo. W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Culebra, Canal Zone.

Payments made by the disbursing department on the Isthmus during fiscal year 1910.

Month.	Gold rolls.	Silver rolls.	Public bills and reimbursement vouchers.	Total.	Items on rolls each month.		
					Gold.	Silver.	Total.
1909.							
July	$693,076.01	$818,673.00	$635,073.39	$2,146,822.40	5,129	31,426	36,555
August	745,132.02	835,885.52	893,738.87	2,474,756.41	5,240	32,529	37,769
September	670,333.96	779,032.01	568,747.18	2,018,113.15	5,269	31,617	36,886
October	737,673.07	785,076.77	1,144,365.40	2,667,115.24	5,199	33,108	38,307
November	704,305.00	799,754.74	641,430.48	2,145,490.22	5,196	35,074	40,270
December	740,164.20	697,987.67	596,014.04	2,034,165.91	5,016	31,940	36,956
1910.							
January	728,406.50	779,160.44	1,144,598.04	2,652,164.98	5,153	33,381	38,534
February	737,627.02	837,641.02	721,941.88	2,297,209.92	5,346	33,814	39,160
March	733,424.85	814,268.62	833,108.62	2,380,802.09	5,318	34,165	39,483
April	747,084.99	906,724.01	877,559.82	2,531,368.82	5,334	35,963	41,297
May	743,090.87	888,649.26	927,058.33	2,558,798.46	5,382	35,658	41,040
June	727,383.70	840,959.64	877,377.32	2,445,720.66	5,303	33,153	38,456
Total	8,707,702.19	9,783,812.70	9,861,013.37	28,352,528.26	62,885	401,828	464,713

NOTE.—In addition to the above the sum of $1,081,778.85 was collected from parties other than employees of the Isthmian Canal Commission and covered into the United States Treasury as miscellaneous receipts United States funds.

Coupon books and meal tickets issued by the disbursing department on the Isthmus, fiscal year 1910.

Months.	Commissary books.				Hotel books.		Meal tickets.		
	$2.50	$5.	$10.	$15.	$15.	$4.80.	30 cents.	40 cents.	No name, no amount.
1909.									
July	6,055	16,015	11,020	....	3,460	80	39,800	47,100	....
August	6,000	11,910	4,018	1,975	4,355	260	67,400	100,200	....
September	8,850	20,025	....	8,446	3,800	285	83,900	54,500	....
October	6,835	20,735	....	5,428	3,167	253	99,500	86,500	....
November	4,775	12,905	....	4,255	3,130	380	51,900	70,800	....
December	6,225	22,005	....	7,226	4,675	495	37,400	55,400	....
1910.									
January	6,659	21,630	....	6,030	4,208	97	45,600	111,500	1,000
February	7,180	20,300	....	6,045	3,860	350	39,700	86,300	2,000
March	8,370	22,025	....	6,920	4,085	385	48,400	99,000	....
April	6,345	23,195	....	6,625	4,785	350	73,800	122,700	100
May	7,295	21,155	....	5,600	2,420	225	44,200	108,400	....
June	8,305	23,070	....	7,250	4,395	310	23,500	101,700	300
Total	82,894	234,970	15,038	65,800	46,340	3,470	655,100	1,044,100	3,400
Value	$207,235	$1,174,850	$150,380	$987,000	$695,100	$16,656	$196,530	$417,640	....
Grand total values	$2,519,465				$711,756		$614,170		....

APPENDIX O.

REPORT OF HON. M. H. THATCHER, MEMBER OF ISTHMIAN CANAL COMMISSION, HEAD OF THE DEPARTMENT OF CIVIL ADMINISTRATION.

Ancon, Canal Zone, *August 1, 1910.*

Sir: I have the honor to submit the report of the department of civil administration of the commission for the fiscal year ended June 30, 1910.

The organization of the department remains substantially as outlined in the last anual report. The undersigned, by the President's order of April 12, 1910, was appointed a member of the Isthmian Canal Commission, arrived on the Isthmus May 13, 1910, and by an order of the same date issued by the acting chairman, agreeably to the President's direction, was placed in charge of the department of civil administration. The position of executive secretary, created September 2, 1904, by act No. 8, of the Laws of the Canal Zone, was abolished by executive order of the Secretary of War dated May 24, 1910. A board of local inspectors, for the examination and licensing of masters, mates, engineers, and pilots of steam vessels navigating the waters of the Canal Zone, was created by the President's order of October 2, 1909, and is attached to the department.

LEGISLATION.

Aside from the provisions contained in the sundry civil appropriation act, respecting the use of revenues of the Canal Zone, the only congressional legislation affecting the Zone passed during the year was an amendment to the act relating to the liability of common carriers by railroad to their employees in certain cases. Executive orders of the President and Secretary of War having the effect of law in the Canal Zone have been promulgated from time to time. Among the most important are the order of the President dated July 30, 1909, amending section 149 of the Penal Code of the Canal Zone, which prescribes the penalties for murder in the first and second degrees; the order of the President dated July 30, 1909, providing for the reduction of sentences of penitentiary convicts for good behavior; the order of the President of September 8, 1909, making it a misdemeanor to hunt at night by the aid of trap guns, torches, bonfires, or other artificial light; the order of the President of October 2, 1909, providing more adequate punishment for cruelty to animals and children; the President's order of November 23, 1909, which penalizes the recruiting, in the Canal Zone, for service in foreign countries, of laborers and workmen; the President's order of October 2, 1909, amending the order of the governor of the Canal Zone respecting the licensing of pilots, mates, engineers, and masters of steam vessels

navigating the waters of the Canal Zone; the order of the President of April 16, 1910, defining the powers and functions of the counsel and chief attorney, and the prosecuting attorney, amending the existing provisions of law respecting the filing of informations and the execution of criminal process; the order of the President of January 26, 1910, providing that an equitable proportion of the cost of sanitary improvements, not to exceed one-half thereof, shall be charged to the owners of property adjacent to, abutting upon, or within the district in which sanitary improvements are made.

The commission at its one hundred and fifty-sixth meeting, held on April 23, 1910, passed an ordinance, which was approved by the Secretary of War on May 12, 1910, providing for the keeping of registers by hotels, boarding and lodging house keepers, and the recording therein of the name, place of last residence, date of arrival on the Isthmus, and date of departure and destination of each guest A violation of its provisions is made a misdemeanor.

The executive order of the Secretary of War of December 1, 1909, amends section 450 of the Penal Code of the Laws of the Canal Zone to permit members of rifle, gun, or pistol clubs, organized in accordance with regulations established by the chief executive of the Zone, to practice at a target range and to carry firearms in going to and from target range without the payment of the regular fee provided by law for the carrying of firearms. Rules and regulations prescribing the manner in which the benefits provided by this order may be secured were approved by the chairman, effective January 4, 1910. Section 456 of the Penal Code was amended by the same order, exempting enlisted men of the U. S. Marine Corps, stationed on the Isthmus of Panama, from the payment of the fee for hunting permits.

An amendment to the building regulations respecting the distances between dwellings not within regularly platted town sites, and the erection of houses near commission buildings, was enacted by the commission at its one hundred and fifty-fifth meeting, December 6, 1909, and approved by the Secretary of War on January 25, 1910.

RELATIONS WITH PANAMA.

Negotiations, by correspondence or personal conference, between the secretary of foreign affairs of Panama and the head of the department of civil administration included, among others, the following subjects in addition to routine matters:

The stationing of Zone police at Nombre de Dios, in the Republic of Panama; the amendment of the agreement with Panama for the maintenance and operation of the Santo Tomas Hospital, in the city of Panama; the maintenance of the insane of the Republic of Panama in the hospitals of the commission; the collections of consular fees by the consuls of Panama on consignments to the Panama Railroad Company; the verification of the survey of the boundaries of the Canal Zone; the adoption of sanitary regulations for Nombre de Dios, in the Republic of Panama; the adoption of uniform coach regulations for Panama-Ancon and Colon-Cristobal; the construction of a railroad from Panama to the city of David, in the Republic of Panama; the establishment at Gatun, by Panama, of a school for Panamanian children residing in that vicinity; the jurisdiction of the Canal Zone fire department in case of fire in the cities of Panama

or Colon; and the enforcement of the executive decree of Panama prohibiting the recruiting of labor in the cities of Panama and Colon.

Various negotiations affecting the Panama Railroad Company, and respecting the customs service and the operation and maintenance of the water, sewer, and paving systems in the city of Panama were also conducted.

The relations of the commission with Panama and with foreign consuls whose jurisdiction extends to the Canal Zone continue satisfactory.

STEAMBOAT-INSPECTION SERVICE.

A board of local inspectors, created by the order of the President dated October 2, 1909, was appointed on November 12, 1909. It consists of three members, all of whom are employed in other capacities by the commission, and receive no additional compensation for service on the board. The board examined 278 applicants for licenses as masters, mates, engineers, or pilots of steam vessels; 262 applicants were issued licenses and 16 applicants were refused licenses. The board also made numerous investigations and inquiries respecting accidents to craft navigating the waters of the Canal Zone, charges of improper conduct on the part of persons to whom it had issued licenses, and violations of the navigation laws.

DIVISION OF POSTS, CUSTOMS, AND REVENUES.

This division includes the postal, customs, and public-land services, the collection of taxes and license fees, and the administration of estates of deceased American employees of the commission and the Panama Railroad Company.

POSTAL SERVICE.

During the year for which this report is submitted the sale of postage stamps and postal cards amounted to $83,765.60 and $81.50 was collected for second-class matter, a total income from postage sales of $83,847.10, as compared with a total of $74,327.40 for the preceding fiscal year, an increase of $9,519.70.

At Cristobal, during the year, there were 1,009 dispatches of mail, included in which there were several dispatches of bullion direct to England. In the same period 151,622 registered letters and parcels were handled. Of this number, 29,082 were domestic letters, 5,766 domestic parcels, 41,114 foreign letters, 1,598 foreign parcels, 71,971 official letters and parcels registered free, and 2,091 letters and parcels re-registered free. It will be noted that of the registered matter approximately 45 per cent was official.

In the post-offices at Cristobal and Ancon, in which are handled foreign registered mail, 113,429 pieces were handled. Of these, 8,778 pieces passed through the Ancon post-office for Panama and Central and South American points, and 104,651 through the Cristobal post-office for points in the United States, the West Indies, and Europe. Seventy-two thousand six hundred and seventy pouches, sacks, and registered sacks were handled by the railway mail messengers during the year.

Two hundred and seven thousand two hundred and twenty money orders were issued during the year for a total of $5,228,562.15, and the fees aggregated $22,980.96. The number and amount of money

orders sold during the past year exceed the sales during the year ended June 30, 1909, by 26,831 and $61,812.69, respectively. The average amount of each order was $25.23, as compared with $28.64 for the previous year. There were paid and repaid during the year orders amounting to $1,389,623.97. Of the money orders sold during the year orders amounting to $3,976,891.63 were payable in the United States and foreign countries, except Martinique, and orders amounting to $1,247,610.22 in the Canal Zone. A convention providing for the direct exchange of postal money orders between Martinique, French West Indies, and the Canal Zone was concluded on August 1, 1909. Since the convention became operative orders amounting to $4,060.30 have been drawn for payment in Martinique. Settlement of accounts is made direct between the respective postal administrations. The number of employees of the commission spending their vacations in Costa Rica has created a demand for a direct exchange of money orders between the Canal Zone and that country, and recommendations were made that negotiations be entered into between the Postmaster-General and the minister of Costa Rica at Washington with a view to concluding such an agreement. The negotiations had not been concluded at the close of the period for which this report is submitted.

There were in the post-offices of the Canal Zone, on November 13, 1909, unpaid money orders aggregating $340,000 drawn to the order of the remitter and payable at the office of issue. The amount of these orders indicates the extent to which the post-offices are used as depositories by employees. On June 30, 1910, the amount of such orders was $323,311.15.

The business transacted in the various branches of the postal division constitutes the source of a large amount of general correspondence, which is conducted in the office of the director of posts, such as correspondence relating to lost and invalidated money orders; issuance of duplicates; tracing of lost or delayed mail; the handling of unclaimed registered matter, of which there were 1,023 pieces during the year; the handling of unclaimed mail matter, amounting to 32,397 pieces, 10,796 being domestic letters and parcels and 21,599 foreign letters and parcels; 1,801 misdirected domestic letters were advertised in the Canal Record, of which about 60 per cent were delivered or forwarded to addressees.

No new buildings were constructed during the year.

CUSTOMS SERVICE.

During the year 237 vessels entered at the port of Ancon, with a total tonnage of 400,910, and 238 vessels cleared, having a tonnage of 399,690. At Cristobal 235 vessels entered, with a tonnage of 636,191, and 232 vessels cleared, with a tonnage of 625,958.

The usual customs services, such as shipping and discharging seamen, the noting of protests, filing of manifests, etc., were rendered seamen and vessels. Under an agreement with Panama, no duties, tolls, or customs fees were collected.

At the port of Ancon 176 Chinese arrived, in transit to the Republic of Panama or other countries. Of this number 157 were permitted to disembark, by authority of the secretary of foreign affairs of the Republic of Panama, and 18 were either transferred to other vessels or returned to the port of embarkation. One escaped.

LANDS.

Leases for lands are made under the same conditions as described in previous annual reports. At the close of business June 30, 1910, there were in force 2,783 leases, of which 1,892 were for building lots and 884 for agricultural lands, an increase of 686 in the total number of leases as compared with June 30, 1909. The area of the agricultural land under lease is 1,545 hectares, or approximately 3,682 acres. Rents collected during the year amounted to $27,282.29, as compared with $26,969.88 for the year ended June 30, 1909. The total collections from this source for the previous fiscal years were, in 1908, $17,436.76, and for 1907, $7,974.78.

An appropriation of $75,000 was made by Congress near the close of the year for the purpose of making a general land survey of the Canal Zone.

TAXES AND LICENSE FEES.

During the year $107,642.58 was collected on account of general taxes and licenses, as compared with $98,970.86 during the year ended June 30, 1909. There was collected as distillation tax $3,158.67, as compared with $2,209 for the fiscal year ended June 30, 1909, and $3,814.94 during the year 1908. Fifty-seven licenses were issued for the sale of liquor at retail. Five licenses were forfeited because of the nonpayment of the fee for the semiannual period January 1–June 30, 1910. The total collections were $65,400, as compared with $72,600 for the previous fiscal year. Two hundred and thirty-four dollars and thirty-four cents was collected during the year as license fees from insurance companies doing business in the Canal Zone.

ADMINISTRATION OF ESTATES.

The collector of revenues, as ex officio administrator of estates, settled 38 estates of American employees of the commission or Panama Railroad, and there were 17 estates in course of settlement on June 30, 1910. The money handled during the year on account of administration of estates aggregated $6,531.24.

Under the provisions of sections 779 and 780, Code of Civil Procedure, 12 estates were during the year escheated to the government of the Canal Zone on petition of the collector of revenues. The value of these estates was $552.25.

MISCELLANEOUS COLLECTIONS.

In addition to the collection of Zone revenues, this division collects for other departments of the commission various bills against employees and others on account of hospital fees, quarantine charges, subsistence, sales of material, etc. These collections during the year aggregated $31,373.03.

The revenues collected by the division during the year aggregated $310,279.57, and the total of all moneys handled was $5,577,285.24.

DIVISION OF POLICE AND PRISONS.

The chief of police, as outlined in former reports, is also marshal of the supreme and circuit courts, warden of the penitentiary, and coroner of the Canal Zone. On June 30, 1910, the force consisted of

a chief, an assistant chief, 2 inspectors, 4 lieutenants, 8 sergeants, 20 corporals, 112 first-class police officers, and 111 policemen.

Under a plan of reorganization, effective February 1, 1910, the Canal Zone was, for police purposes, divided into four districts, coextensive with the administrative districts as established by the order of the President dated March 13, 1907. In each of these districts there is a central station, at the place where the district court is located, and all other police stations in the district, termed substations, are under the direct control of the lieutenant of police, whose headquarters are at the central station. A member of the police force at each of the central stations is designated as deputy marshal of the circuit court of the circuit in which the station is situated. The changes in the organization of the division were made with a view to concentrating the responsibility.

Six thousand nine hundred and forty-seven arrests were made during the year, 6,407 of which were males and 477 females, as compared with 5,760 males and 515 females, or a total of 6,275 for the previous year. This represents an increase of about 10 per cent in the number of arrests and may be attributed in part to the general increase of population in the Canal Zone, as well as the increase in the number of persons not in the employ of the commission or the Panama Railroad Company. Of the total number of persons arrested 80 per cent thereof, or 5,467, were subsequently convicted, 1,211 were dismissed, and the cases of 34 had not been disposed of at the end of the year. Of the remainder of the persons arrested, 40 were confined in the insane asylum at Ancon, 22 were turned over to the military authorities, 11 deserters were returned to the ships from which they deserted, and 14 fugitives from justice of Panama were delivered to that Government. One hundred and forty-eight persons arrested at Porto Bello, in the Republic of Panama and included in the total given above, were turned over to the authorities of the Republic of Panama for trial.

There were 16 homicides during the year. In 14 cases 18 arrests were made; 5 were convicted, 8 acquitted, 1 dismissed, 1 confined in the asylum for the insane at Ancon, and 3 are awaiting trial.

Substations were established during the year at Monte Lirio and Toro Point. The station building at Gatun was enlarged to double its original capacity for both prisoners and police personnel, the addition having been made necessary because of the increase in population and consequent police activities at that point. No new buildings were constructed during the year.

On June 30, 1910, there were 138 felony convicts confined in the penitentiary at Culebra, as compared with 117 on July 1, 1909, and 108 on July 1, 1908. One hundred and thirty-seven began penitentiary sentences during the year; 116 were discharged.

All convicts have been kept at work on public works in the Zone, except a sufficient detail to perform necessary work at the penitentiary. Misdemeanor convicts were also used on public improvements wherever practicable.

The value of the work performed by the penitentiary convicts was $21,167.02 and the cost of guarding, subsisting, and clothing them was $35,428.76.

One thousand five hundred and ninety-three writs of process in civil cases were served during the year. One hundred and forty-three

deaths were investigated by the chief of police, or other members of the force, acting as coroner or deputy coroners. Of these 37 resulted from drowning and 45 from railroad accidents.

During the year 101 persons of undesirable character were deported from the Canal Zone. At the expiration of their sentences all convicted felons alien to the Canal Zone, and who had not established their residence in the Canal Zone prior to February 26, 1904, are deported. The total given includes such convicts.

Eight pardons were granted during the year, and 2 sentences were commuted.

DIVISION OF FIRE PROTECTION.

The work of this division remains as described in previous reports. During the year a paid company was established at Gatun. The building is a two-story frame building, 22 by 50 feet, of the usual type of commission buildings. The ground floor consists of an apparatus room 22 by 40 feet, and a storeroom 22 by 10 feet. On the second floor the space is used as sleeping quarters for the personnel of the station, and as a battery room for the alarm system. The station is equipped with a two-horse Seagrove hose wagon, carrying 1,200 feet of 2½-inch rubber-lined hose, a 20-foot extension ladder, a 14-foot roof ladder, and two 3-gallon chemical extinguishers. An increase in the personnel of the division of two firemen, in addition to the company of firemen at Gatun, was authorized during the year, as the value of the property of the commission at Corozal and Pedro Miguel required the detail of paid firemen to those points. Two new volunteer companies were organized at Gatun during the year, and one volunteer company was discontinued at Ancon. On June 30, 1910, there were 19 volunteer companies, with a total of 324 members. A 10-box alarm system of the type used at the other stations on the Zone was placed in operation at Gatun during the year, making a total of five systems in operation. All of the systems were inspected, tested, and kept in working order by the electrician of the division. At the close of the year there were in use 38,250 feet of 2½-inch rubber-lined hose, 17,320 feet of 2½-inch unlined hose, and 305 nozzles. One thousand four hundred and sixty-one chemical fire extinguishers were under the care of the division on June 30, 1910. Thirty-three thousand four hundred and twenty-one inspections and 281 recharges of chemical extinguishers were made, and 1,149 extinguishers were repainted. The inspection of buildings and fire-fighting apparatus distributed throughout the Zone and in buildings of the United States and the Panama Railroad in the cities of Panama and Colon, on Culebra and Taboga islands, at the Palo Seco Leper Asylum, and at Porto Bello and Nombre de Dios, was maintained.

One hundred and thirty-three alarms of fire were responded to during the year, 10 of which were false alarms. Of the 123 actual fires, 11 were in the city of Panama and 1 in the city of Colon; 77 fires were in government property and 15 in property of the Panama Railroad Company. The value of government and railroad property involved, including the buildings and their contents, as reported by the fire chief, was $1,174,017.19, and the total loss is estimated at $2,050.22 in government property and $745.82 in property of the Panama Railroad Company. The average loss in all fires in government and Panama Railroad property was $30.40. The loss in the 7 larger fires

was $2,430.54, while the amount of property involved is estimated at $10,442. The fire in the Pacific division storehouse at Culebra on January 10, 1910, resulted in a total loss estimated at $1,100. An alarm was not turned in for this fire until the building had been practically consumed, and it had collapsed when the Culebra paid department arrived. In the fire in a dwelling house, the property of the Panama Railroad Company, in Colon, on September 4, 1909, the loss sustained is estimated at $550. The value of the building was estimated at $1,475. The building was situated over a mile from the Cristobal fire station, and the fire had gained considerable headway before the department arrived. The fire in an oil storehouse at Corozal resulted in a loss of $265.95, and the death of the negro storekeeper. The building and contents were valued at $1,405. The fire was extinguished by the volunteer company at Corozal. The value of private property involved in the 31 fires reported is estimated by the fire chief at $35,418 and the loss at $441.

Satisfactory relations were maintained with the fire departments of the cities of Panama and Colon. Numerous recommendations were made by the fire chief for the extension of water mains, the installation of fire hydrants, and the extension of roads, to increase the efficiency of the division.

DIVISION OF PUBLIC WORKS.

The work of this division remains as described in previous reports.

In Panama there were on June 30, 1909, 1,292 connections with the water and sewer mains, and 87 applications pending. On June 30, 1910, there were 1,493 connections and 84 applications for connections pending, an increase of 201 connections during the year. The installation of all plumbing resulting from these new connections, as well as repairs and extensions to existing plumbing, was inspected by the employees of the division.

The collections of water rents from private consumers for the first three quarters of the year were $50,159.15, and the net amount of the bills rendered for the quarter ended June 30, 1910, was $16,384, a total for the year of $66,543.15. The collections from private consumers during the quarter ended March 31, 1910, were $16,067.50, and the net amount of the bills rendered for the quarter ended June 30 is $16,384. Panama was therefore required to pay, for the quarter ended March 31, $339.10, and will be required to pay $16 for the quarter ended June 30, unless delinquent penalties amount to $16 to bring the collections up to the amount guaranteed. During the first two quarters the collections exceeded the amount guaranteed, and no payment by Panama was necessary. As Panama makes no direct payment for public hydrants and taps the amount paid by it on account of deficient collections may be said to cover the water furnished through these hydrants and public taps, and the average charge for each hydrant and tap was therefore $2.11 per annum. The amount paid by Panama during the year ended June 30, 1909, was $1,602.35, and during the year ended June 30, 1908, $6,631.75, an average charge per hydrant or tap for those years, respectively, of $9.77 and $39.47. The population of the city of Panama is estimated at 43,733. The average daily consumption of water per capita was 22.6 gallons. The average annual charge per connection was $48.36.

The work of extending the water and sewer mains to the outlying portions of the city of Panama, authorized by the act of Congress approved March 4, 1909, had progressed sufficiently during the year to make possible the installation of plumbing in a number of houses in those sections of the city. The water mains, hydrants, valves, taps, etc., were kept in order during the year. Meters were tested, repaired, and set, as needed, and sewers, manholes, and catch basins were kept clean and in working order. The brick paving in the city of Panama is wearing well and but few repairs have been necessary. The two most largely used macadam streets have, however, required considerable attention, and minor repairs have been necessary to other macadam streets.

In Colon on June 30, 1909, there were 464 connections using water and 27 applications for connections pending. On June 30, 1910, there were 548 connections using water and 28 applications for connections pending, an increase during the year of 84 connections. The installation of plumbing resulting from the connections and the repairs and extensions to existing plumbing were inspected by employees of the division. The water connections with property of the Panama Railroad Company or the Isthmian Canal Commission are not included in the number of connections given above. The collections in Colon from private consumers and from the commission and Panama Railroad Company during the first three quarters of the year were $56,477.45, and the net amount of bills rendered for the fourth quarter was $19,507.90, a total for the year of $75,985.35. As the collections during each quarter have exceeded the amount guaranteed by the Panama Government, the water furnished through 84 public hydrants and taps may be said to have been furnished free. Estimating the population of Colon at 18,737, the average daily consumption per capita was 37.97 gallons. The average annual charge per connection was $121.26. The same character of maintenance work was performed in Colon as in Panama. Extensive repairs were necessary to the macadam streets, four blocks were resurfaced, and numerous repairs were made to the concrete curbs and gutters.

The extension of the water, sewer, and paving systems in both Panama and Colon, authorized by Congress, will require the amendment of existing agreements with Panama for the collection of water rents to amortise the cost of those improvements. Panama has been advised that as soon as data are available drafts of new contracts will be submitted. It is not believed at this time that an increase in the water rates to consumers will be necessary. These rates are for Panama 25 cents net per 1,000 gallons and for Colon 40 cents.

In the Canal Zone on June 30, 1909, there were 272 private connections with the water and sewer mains. On June 30, 1910, there were 516 connections, an increase of 244. All of the plumbing installations resulting from these connections, as well as the repairs and extensions to existing plumbing, were inspected by employees of the division. The water rates in the Canal Zone were not changed during the year. Bills of a net amount of $12,239.65 were prepared and forwarded to the collector of revenues for collection, as compared with $7,364.35 during the previous year. Extensions of the water and sewer systems in the Canal Zone were made in the native villages of West Culebra, Empire, Bas Obispo, and New Gatun. Temporary

public taps were made for residents in the native villages of Las Cascadas and Paraiso. A new public market was constructed during the year at Gatun, and there were at the end of the year nine markets in operation. At the two public slaughterhouses of the Zone 3,170 cattle, 1,177 hogs, and 17 goats were slaughtered.

Recommendations were made or advice given respecting other public improvements in the Zone paid for from funds raised by taxation, and are described elsewhere in this report.

DIVISION OF SCHOOLS.

The schools for the year 1909–10 opened on October 1, 1909, with an enrollment in that month of 1,812 children—745 in the white and 1,067 in the colored schools. The highest monthly enrollment was in February, when 813 pupils were enrolled in the white schools and 1,169 in the colored schools.

Twelve schools for white children and 15 for colored children were maintained throughout the year. Two additional colored schools were maintained a part of the year. Practically all of the schools are equipped with adjustable desks, and requisition was made in June for sufficient additional desks to properly equip all schools next year. The low attendance at the colored schools at Frijoles and Savanas made the discontinuance of those schools necessary.

Early in the year plans were approved for the establishment of a central high school to provide adequately for the high-school pupils attending the schools at Culebra, Gatun, and Cristobal (where temporary provision had theretofore been made for their instruction), and the high school was opened on December 6, with an enrollment of 52 pupils. The pupils are transported by rail daily from and to their homes. It is believed that the results attained justified the increase travel of pupils. The subjects taught are the same as those named in the last annual report.

School gardens were maintained in connection with the colored schools at Balboa, Culebra, Empire, Las Cascadas, and Gatun. The horticulturist formerly employed by the commission was detailed to duty with the division of schools for a month to assist in the development of the school gardens. The total area of the school gardens is approximately 3½ acres, and the value of the products sold by pupils was $332.72. The children of these schools have manifested great interest in the work.

By resolution of the commission, the rates of tuition for children of nonresidents of the Canal Zone who are not employees of the commission or the Panama Railroad Company were increased from $2 per month for grade schools and $4 per month for the high school to $4 and $8, respectively.

The medical examinations of pupils, inaugurated last year and described in the last annual report, were continued during the year covered by this report. A high rate of attendance in the Canal Zone, as indicated in the last annual report, is difficult to secure, and was not materially increased during the past year.

New buildings were constructed for the colored schools at Culebra and Gatun, and two-room additions were made to the white schools at Gorgona and Cristobal and to the colored school at Cristobal.

PROSECUTING ATTORNEY'S OFFICE.

During the year the prosecuting attorney, who is in charge of the prosecution before the courts of offenses against the penal laws of the Zone, filed in the circuit courts 234 informations charging felonies; proceedings were had against 275 defendants, and 177 defendants were convicted. Seventeen informations, charging misdemeanors, were filed in the circuit courts against 38 defendants, and 28 convictions were had. The prosecuting attorney also represented the Government in 71 criminal cases, involving 89 defendants, appealed to the circuit courts from the district courts, and 63 defendants were convicted.

CANAL ZONE FUNDS.

The act of Congress approved March 4, 1909, authorized the use of Zone revenues for the payment of miscellaneous and contingent expenses of the Zone government; the construction, maintenance, and operation of public works and public improvements; the maintenance of the public schools; the maintenance of administrative districts of the Zone, including the payment of salaries and wages of tax collectors, inspectors, district judges, etc ; the maintenance of pauper sick of the Zone in the hospitals of the commission; the maintenance of misdemeanor prisoners serving sentences in the jails of the Zone; and, so far as the postal revenues go, the maintenance of the postal service.

At the beginning of the fiscal year there was $197,531.22 on hand in the Zone treasury, and during the year there was collected $394,422.23. The expenditures amounted to $518,771.57. The estimated revenues of the Canal Zone during the current fiscal year are $270,000, exclusive of postal receipts, and will be expended approximately as follows:

Maintenance of schools	$98,500
Expenses of district courts	19,250
Expenses of district tax collectors' offices	13,100
Maintenance of pauper sick in Isthmian Canal Commission hospitals	2,500
Maintenance of misdemeanor prisoners	15,000
Maintenance of markets and slaughterhouses	4,250
Construction, repair, maintenance, and operation of roads, trails, bridges, waterworks and sewers, night-soil and garbage removal, and street cleaning in native villages, and other miscellaneous public works and improvements	107,400
Miscellaneous and contingent expenses	10,000
	270,000

The postal revenues during the current year will, it is estimated, amount to approximately $100,000, and they will be applied toward the maintenance of the postal service.

COURTS.

The supreme court held 19 sessions during the year. It affirmed the decision of the circuit court in 2 criminal cases, and reversed the decision of that court in 1 criminal case. Three civil cases were pending in the court at the beginning of the year, 13 were filed, and 10 were disposed of. Five attorneys were admitted by the court during the year.

In the circuit courts 382 criminal cases were filed. The defendants in 249 cases were convicted, and 39 were acquitted. Sixty-eight cases were dismissed, and 26 cases were pending on June 30. There were 397 civil cases filed during the year, 301 were disposed of, and 96 were pending at the end of the year.

In the district courts 6,732 criminal cases were filed. The defendants were convicted in 5,215 cases, and acquitted in 812 cases. Three hundred and sixty-six cases were appealed to the circuit courts, and 9 cases were pending on June 30. One thousand one hundred and twenty-three civil cases were filed during the year; 1,055 were disposed of, and 68 were pending at the close of the year.

Attention is called to the statements attached as appendices to this report, which indicate in detail the business transacted throughout the department.

Very respectfully,

M. H. Thatcher,
Head of Department of Civil Administration.

Col. George W. Goethals, U. S. Army,
Chairman Isthmian Canal Commission,
Culebra, Canal Zone.

APPENDICES TO REPORT OF THE HEAD OF THE DEPARTMENT OF CIVIL ADMINISTRATION.

Appendix I.

Appendix II.

Appendix III.

Table 32.—Consumption of water, collections made, and bills outstanding for water rents in the city of Panama for the fiscal year ended June 30, 1910.
Table 33.—Consumption of water, collections made, and bills outstanding for water rents in the city of Colon for the fiscal year ended June 30, 1910.

Appendix IV.

Table 34.—Monthly enrollment and average daily attendance in white and colored schools during the fiscal year ended June 30, 1910.
Table 35.—Total enrollment, by schools, during the fiscal year ended June 30, 1910.
Table 36.—Enrollment, by grades, during the fiscal year ended June 30, 1910.
Table 37.—Number of teachers employed in white and colored schools and number of days of sickness of teachers during the fiscal year ended June 30, 1910.
Table 38.—Statement of the value of products raised in school gardens.

Appendix V.

Table 39.—Revenues collected from July 1, 1909, to June 30, 1910.
Table 40.—Expenditures from July 1, 1909, to June 30, 1910.
Table 41.—Receipts and disbursements from July 1, 1909, to June 30, 1910, by appropriations.

Appendix VI.

Table 42.—Business transacted in the supreme court of the Canal Zone.
Table 43.—Business transacted in the first circuit court.
Table 44.—Business transacted in the second circuit court.
Table 45.—Business transacted in the third circuit court.
Table 46.—Business transacted in the district court of the district of Ancon.
Table 47.—Business transacted in the district court of the district of Empire.
Table 48.—Business transacted in the district court of the district of Gorgona.
Table 49.—Business transacted in the district court of the district of Cristobal.

Appendix VII.—*Legislation.*

1. Executive order, July 21, 1909, amending act No. 24, and providing for the administration of estates of deceased employees not exceeding in value the sum of $1,000.
2. Executive order, July 30, 1909, amending section 149 of the penal code, and providing penalties for murder in the first and second degrees.
3. Executive order, July 30, 1909, providing for reduction of sentences of convicts on account of good behavior.
4. Executive order, September 8, 1909, amending section 454 of act No. 14, and making the hunting at night with a lantern, torch, or with trap guns, etc., a misdemeanor.
5. Executive order, October 2, 1909, amending executive order of the governor of the Canal Zone of December 8, 1905, and providing for the examination and licensing of pilots.
6. Executive order, October 2, 1909, amending act No. 14, and making the cruel treatment of children and animals a misdemeanor.
7. Executive order, October 15, 1909, exempting in certain cases indemnity insurance companies from payment of annual fee and license tax.
8. Executive order, November 23, 1909, making the recruiting of laborers on the Canal Zone for service in a foreign country a misdemeanor, and providing the penalty therefor.
9. Executive order, December 1, 1909, amending section 450 of act No. 14, and providing for the licensing of persons belonging to rifle, gun, or pistol clubs.
10. Executive order, January 26, 1910, providing for the assessing of one-half of the costs of construction of streets, roads, sewer systems, and similar sanitary improvements against adjacent property owners.
11. Executive order, April 2, 1910, providing that the collection of moneys to be paid for liquor licenses shall be made by the collector of revenues or his deputy or assistant.
12. Executive order, April 16, 1910, prescribing the powers and functions of the counsel and chief attorney for the Isthmian Canal Commission.

13. Ordinance of April 23, 1910, providing for the keeping of registers by hotels and boarding and lodging houses.
14. Regulations for the government of rifle, gun, or pistol clubs under the provisions of the executive order of December 1, 1909.
15. Amendment to paragraph 4 of the building regulations, providing a limit of distance that shall separate dwellings to be constructed in the Canal Zone, and approved by the Secretary of War, January 25, 1910.

APPENDIX VIII.

TABLE 50.—Licenses issued by the board of local inspectors during the fiscal year ended June 30, 1910.

APPENDIX IX.

TABLE 51.—Statement of fires during the fiscal year ended June 30, 1910.

APPENDIX I.—DIVISION OF POSTS, CUSTOMS, AND REVENUES.

TABLE 1.—*Sale of postage stamps and collections on account of second-class mail matter, by months, during the fiscal year ended June 30, 1910.*

Month.	First class.	Second class.	Month.	First class.	Second class
1909.			1910.		
July	$6,161.00	$13.30	January	$8,320.50	$2.36
August	5,944.00	14.51	February	6,920.00	3.20
September	6,617.00	10.80	March	8,223.00	3.75
October	6,429.00	12.71	April	7,442.50	4.33
November	5,664.00	4.39	May	6,584.00	2.32
December	8,139.00	4.38	June	7,321.00	5.45
			Total	83,765.00	81.50

TABLE 2.—*Letters and parcels registered, by offices, during the fiscal year ended June 30, 1910.*

Name of post-office.	Domestic letters registered.	Domestic parcels registered.	Foreign letters registered.	Foreign parcels registered.	Official, registered free.	Distribution, reregistered free.	Total.
Ancon	4,129	1,045	5,769	325	16,577		27,845
Balboa	1,832	209	1,595	25	2,119	64	5,844
Bas Obispo	903	135	785	7	2,071	183	4,084
Bohio	249	3	685	3	498		1,438
Corozal	878	102	350	16	1,938	21	3,305
Cristobal	7,132	1,124	10,249	108	6,824	470	25,907
Culebra	1,900	389	2,871	62	5,007	41	10,270
Empire	3,316	469	5,153	53	20,523	664	30,178
Gatun	2,485	836	4,641	452	3,727	211	12,352
Gorgona	2,083	645	1,705	33	3,314	41	7,821
Las Cascadas	944	203	1,444	33	1,243	110	3,977
Matachin	244	38	867	291	40		1,480
Miraflores	267	51	839	72	1,506	15	2,750
Paraiso	688	143	1,436	19	1,040		3,326
Pedro Miguel	1,268	236	1,182	73	2,057	63	4,879
San Pablo	301	54	713	16	1,890	132	3,106
Tabernilla	463	84	830	10	1,597	76	3,060
Total	29,082	5,766	41,114	1,598	71,971	2,091	151,622

TABLE 3.—*Number of dispatches of mail from the exchange office at Cristobal, and number of pouches, sacks, and registered sacks handled by railway mail messengers during the year ended June 30, 1910.*

Month.	Pouches.	Sacks.	Registered sacks.	Total.	Dispatches.
1909.					
July	4,548	1,201	229	5,978	82
August	6,162	1,093	220	6,475	89
September	4,878	1,145	311	6,334	81
October	5,187	1,357	332	6,876	85
November	4,054	728	173	4,955	80
December	4,578	1,372	388	6,338	84
1910.					
January	4,685	1,195	248	6,128	83
February	4,292	1,250	296	5,838	74
March	4,707	1,458	363	6,538	88
April	4,910	1,094	332	6,336	91
May	4,453	936	260	5,649	87
June	3,643	1,423	159	5,225	85
Total	55,097	14,252	3,311	72,670	1,009

TABLE 4.—*Destination of dispatches of mail by the exchange office at Cristobal during the fiscal year ended June 30, 1910.*

To—	Dispatches.	To—	Dispatches.
New York, by Panama R. R., Royal Mail, Hamburg-American steamers	97	St. Vincent	2
New Orleans, La. (States mail)	54	England (via Southampton and Royal Mail Steam Packet Co.)	1
Jamaica	71	Cartagena, Colombia	3
Barbados and Dis	31	Mobile, Ala. (via L. H. S. S. Co.)	1
Trinidad and Dis	32	Philadelphia, Pa. (via U. S. S. Dixie, States mail)	1
Port Limon, Costa Rica	55	U. S. S. Des Moines at Bocas del Toro, Panama	4
French lines—Colon-Bordeaux, Colon-St. Nazaire	26	Marines at Bluefields, Nicaragua, U. S. S. Prairie	2
Martinique, via French Line	24	Colon, Panama	570
Guadeloupe, via French Line	24		
Antigua	7		
British Guiana	2		
Grenada	2	Total	1,009

TABLE 5.—*Money orders issued, by months, during fiscal year ended June 30, 1910.*

	Orders issued.	On the United States.[a]	On the Canal Zone.	On Martinique.	Amount.	Fees.
1909.						
July	15,434	$306,131.63	$111,246.47	....	$417,378.10	$1,790.08
August	15,466	309,540.07	99,913.15	$28.00	409,481.22	1,764.51
September	16,331	311,734.23	105,795.77	273.50	417,803.50	1,826.17
October	16,608	323,721.09	107,386.88	313.50	431,421.47	1,871.50
November	18,143	344,723.61	97,199.80	373.50	442,296.91	1,979.07
December	19,862	368,612.65	91,214.93	486.50	460,314.08	2,088.66
1910.						
January	16,670	320,354.84	101,211.26	479.10	422,045.20	1,850.32
February	17,228	330,957.93	96,413.09	460.00	427,831.02	1,894.54
March	19,596	366,095.81	114,837.36	582.50	481,515.67	2,136.20
April	18,246	348,882.94	107,140.63	345.50	456,369.07	2,011.45
May	16,853	329,893.32	108,743.07	375.00	439,011.39	1,907.31
June	16,783	316,243.51	106,507.81	343.20	423,094.52	1,861.15
Total	207,220	3,976,891.63	1,247,610.22	4,060.30	5,228,562.15	22,980.96

[a] Orders on West Indies and foreign countries, Martinique excepted.

Average amount of orders, $25.23.

TABLE 6.—*Money orders paid and repaid during fiscal year ended June 30, 1910.*

Month.	Amount.	Month.	Amount.
1909.		1910.	
July	$138,637.14	January	$94,757.14
August	115,308.47	February	94,784.62
September	121,090.42	March	115,674.51
October	97,097.82	April	136,328.26
November	93,560.76	May	126,383.32
December	116,113.42	June	139,888.09
		Total	1,389,623.97

TABLE 7.—*Amount of money orders, by offices, payable to the remitter and drawn on the issuing office, remaining unpaid on June 30, 1910.*

Office.	Amount.	Office.	Amount.
Ancon	$15,922.50	Las Cascadas	$20,844.45
Balboa	20,589.00	Matachin	8,321.50
Bas Obispo	11,510.75	Miraflores	11,110.00
Corozal	12,758.25	Paraiso	13,180.00
Cristobal	35,740.55	Pedro Miguel	34,898.50
Culebra	21,872.50	San Pablo	10,498.30
Empire	18,820.35	Tabernilla	12,488.00
Gatun	31,800.00		
Gorgona	42,956.50	Total	323,311.15

TABLE 8.—*Customs operations at the port of Ancon during the fiscal year ended June 30 1910.*

Nationality.	Class.	Entering.		Clearing.	
		Number.	Tonnage.	Number.	Tonnage.
American	Steam	67	138,474	67	137,813
Do	Sail			1	31
British	Steam	127	182,944	126	179,598
Do	Sail	1	1,768	1	1,768
Chilean	Steam	26	47,081	26	46,855
German	do	2	5,483	3	8,465
Norwegian	do	4	10,020	4	10,020
Peruvian	do	10	15,140	10	15,140
Total		237	400,910	238	399,690

Number of vessels in port from last year		7
Tonnage in port from last year		8,732
Number of vessels remaining in port		6
Tonnage remaining in port		9,952
Services to American seamen:		
Seamen shipped		498
Seamen discharged		583
Seamen deserted		14
Seamen deceased		1
Movement of passengers and cargo:		
Tons of cargo arriving—		
In transit		134,214
Local		58,359
Tons of cargo departing—		
In transit		167,246
Local		537
Passengers arriving—		
Cabin	2,883	
Steerage	1,984	
Total		4,867
Passengers departing—		
Cabin	2,345	
Steerage	1,374	
Total		3,719
Services to Chinese:		
Chinese arriving		176
Chinese transferred to other ships		17
Chinese returned to port of embarkation		1
Chinese escaped		1

TABLE 9.—*Customs operation at the port of Cristobal during the fiscal year ended June 30, 1910.*

Nationality.	Class.	Entering.		Clearing.	
		Number.	Tonnage.	Number.	Tonnage.
American	Steam	84	328,611	83	322,416
British	do	63	130,227	60	125,402
Do	Sail	1	298	1	298
Norwegian	Steam	74	165,369	75	166,156
German	do	3	4,562	3	4,562
Swedish	do	1	1,473	1	1,473
Italian	do	1	2,782	1	2,782
Danish	do	1	2,375	1	2,375
Panamanian	Sail	7	494	7	494
Total		235	636,191	232	625,958

Number of vessels in port from last year		3
Tonnage in port from last year		7,484
Number of vessels remaining in port		6
Tonnage remaining in port		17,717
Services to American seamen:		
Seamen shipped		64
Seamen discharged		37
Seamen deserted		29
Seamen deceased		0
Movement of passengers and cargo:		
Tons of cargo arriving—		
In transit		58,113
Local		928,164
Tons of cargo departing—		
In transit		78,342
Local		46,776
Passengers arriving—		
Cabin	6,642	
Steerage	2,840	
Total		9,482
Passengers departing—		
Cabin	5,683	
Steerage	1,112	
Total		6,795

TABLE 10.—*Distillation taxes collected during the fiscal year ended June 30, 1910.*

Month.	Licenses.	Amount.	Month.	Licenses.	Amount.
1909.			1910.		
July	11	$717.30	January	4	$94.06
August	10	349.25	February	4	117.91
September	7	225.55	March	5	175.22
October	7	225.03	April	8	241.26
November	6	238.47	May	9	359.19
December	7	245.71	June	5	169.72
			Total	83	3,158.67

TABLE 11.—*Collections on account of saloon licenses during fiscal year ended June 30, 1910.*

	July 1, 1909.		January 1, 1910.	
	Licenses.	Amount.	Licenses.	Amount.
Ancon	0		0	
Cristobal	9	$5,400	9	$5,400
Empire	30	18,000	25	15,000
Gorgona	18	10,800	18	10,800
Total	57	34,200	52	31,200

NOTE.—Five licenses lapsed January 1, 1910.
Total amount, $65,400.

TABLE 12.—*Land and building rents collected during the fiscal year ended June 30, 1910.*

Month.	Lands.	Buildings.	Total.
1909.			
July	$1,988.99	$446.00	$2,434.99
August	1,026.21	451.00	1,477.21
September	1,210.00	196.00	1,406.00
October	1,674.26	161.00	1,835.26
November	2,409.27	701.00	3,110.27
December	1,940.09	161.00	2,101.09
1910.			
January	3,462.85	973.35	4,436.20
February	1,390.88	410.00	1,800.88
March	2,162.45	374.00	2,536.45
April	2,321.46	710.00	3,031.46
May	1,184.58	207.00	1,391.58
June	1,515.90	205.00	1,720.90
Total	22,286.94	4,995.35	27,282.29

NOTE.—Collections by administrative districts included in these collections.

TABLE 13.—*Statement, by months, of estates of deceased American employees administered by the administrator of estates during the fiscal year ended June 30, 1910.*

	Received.	Settled.	Amount of funds collected.
On hand and unsettled July 1, 1909	18		
1909.			
July	3	5	$106.35
August	3	2	476.37
September	5	5	1,590.60
October	4	0	157.08
November	2	4	389.84
December	3	4	320.47
1910.			
January	3	3	1,054.35
February	2	4	308.43
March	4	2	95.35
April	3	1	1,215.03
May	5	4	627.55
June	0	4	189.82
Total	55	38	6,531.24

Number of estates remaining unsettled June 30, 1910 17

TABLE 14.—*Estates escheated to the Canal Zone government on petition of the collector of revenues during the fiscal year ended June 30, 1910.*

	Number.	Amount.		Number.	Amount.
1909.			1910.		
July	1	$23.00	January	0	
August	7	478.98	February	0	
September	0		March	0	
October	0		April	0	
November	0		May	0	
December	0		June	4	50.27
			Total	12	552.25

APPENDIX II.—DIVISION OF POLICE AND PRISONS.

TABLE 15.—*Authorized strength of division of police and prisons June 30, 1910.*

Official title.	Number.	Salary.	Official title.	Number.	Salary.
Chief of police	1	$4,000	Policemen	11	$600
Assistant chief of police	1	3,300	Do	40	540
Inspectors	2	2,100	Do	60	480
Lieutenants	4	1,920	Senior clerk	1	1,950
Sergeants	4	1,890	Clerk	1	1,800
Do	4	1,710	Do	1	1,650
Corporals	10	1,620	Clerks	2	1,500
Do	10	1,470			
First-class policemen	20	1,290	Total authorized strength of division	268	....
Do	40	1,080			
Do	16	960			

TABLE 16.—*Actual strength of division of police and prisons on June 30, 1904–1910.*

Official title.	1904.	1905.	1906.	1907.	1908.	1909.	1910.
Chief of police	1	1	1	1	1	1	1
Assistant chief of police							1
Chief clerk		1	1	1	1	1	
Senior clerk							1
Clerks	1	4	5	6	8	5	4
Copyist					1		
Inspectors							2
First lieutenant	1	1	1	1	1	1	
Second lieutenant			1	1	1	1	
Lieutenants							4
First-class sergeants		4	9	6			
Sergeants	6	4	9	6	10	11	8
Corporals	2	3	15	13	18	18	20
First-class policemen		16	23	59	108	117	112
Policemen	75	98	155	90	93	96	111
Engineer, police launch						1	
Sailor, police launch						1	
Total	86	132	220	184	242	253	264

TABLE 17.—*Strength of stations and substations on July 1, 1909.*

[The indentation indicates a substation.]

Station.	Strength.	Station.	Strength.
Headquarters	7	Gorgona	15
Ancon	24	Matachin	9
Las Sabanas	5	San Pablo	3
Balboa	13	Tabernilla	4
Corozal	4	Frijoles	1
Miraflores	6	Bohio	3
Pedro Miguel	5	Gatun	21
Paraiso	5	Cristobal	27
Cucaracha	1	Mount Hope	4
Culebra	11	Colon Hospital	3
Empire	28	Porto Bello	4
Cerro	1	Penitentiary	28
Las Cascadas	7		
Bas Obispo	3	Total	242

TABLE 18.—*Actual strength of stations and substations on June 30, 1910.*

[The indentation indicates a substation.]

Station.	Strength.	Station.	Strength.
Headquarters	7	Gorgona	26
Ancon	29	Bas Obispo	4
Balboa	20	Matachin	5
Las Sabanas	7	San Pablo	2
Corozal	3	Tabernilla	4
Miraflores	4	Frijoles	1
Pedro Miguel	5		42
	68	Cristobal	41
Empire	26	Bohio	4
Paraiso	4	Gatun	21
Cucaracha	1	Monte Lirio	1
Culebra	11	Mount Hope	5
Las Cascadas	4	Porto Bello	4
	46	Toro Point	1
			77
		Penitentiary	24
		Total	264

TABLE 19.—*Number of arrests, by fiscal years, made in the Canal Zone since organization of division of police and prisons.*

Period.	Arrests.	Period.	Arrests.
June 2, 1904, to June 30, 1905	2,130	July 1, 1908, to June 30, 1909	6,275
July 1, 1905, to June 30, 1906	3,748	July 1, 1909, to June 30, 1910	6,947
July 1, 1906, to June 30, 1907	5,831	Total	31,006
July 1, 1907, to June 30, 1908	6,075		

TABLE 20.—*Number of arrests, by months, made during fiscal year ended June 30, 1910.*

Month.	Arrests.	Month.	Arrests.
1909.		1910.	
July	529	January	533
August	535	February	556
September	559	March	662
October	606	April	614
November	464	May	657
December	616	June	616
		Total	6,947
		Arrests with warrant	1,177
		Arrests without warrant	5,770

TABLE 21.—*Statement of convictions of persons arrested during fiscal year ended June 30, 1910.*

	Total arrested.	Convictions.		Total arrested.	Convictions.
1909.			1910.		
July	529	377	January	533	434
August	535	393	February	556	458
September	559	436	March	662	538
October	606	496	April	614	498
November	464	376	May	657	505
December	616	490	June	616	466
			Total	6,947	5,467

Cases continued, 34.

TABLE 22.—*Charges against persons arrested during the fiscal year ended June 30, 1910.*

Offense.	Male.	Female.	Total.
Accessory to felony	1		1
Adultery	9	6	15
Arson	3		3
Assault	77	6	83
Assault and battery	387	24	411
Assault with a deadly weapon	54	1	55
Assault with intent to kill	5		5
Attempt to commit rape	1		1
Attempted larceny	1		1
Attempt to assault	5	2	7
Attempt to defraud	62	6	68
Attempted robbery	1		1
Battery	87	3	90
Bigamy	1	1	2
Bribery	1		1
Bringing stolen property into Canal Zone	6		6
Burglary	52	1	53
Carrying concealed weapons	40		40
Causing false arrest	3		3
Circulating obscene literature	3		3
Conspiracy	1		1
Contempt of court	39	5	44
Crime against nature	7		7
Cruelty to animals	102	2	104
Criminal negligence	1		1
Defilement	1		1
Detained for investigation	39	1	40
Desertion from merchant ship	9		9
Desertion from United States Marine Corps	15		15
Desertion from United States Navy	2		2
Detained as witness	4		4
Discharging firearms	2		2
Disorderly conduct	1,075	120	1,195
Disturbing the peace	581	92	673
Embezzlement	55	3	58
Escaping from jail	1		1
Escaping from insane asylum	4		4
Extortion	1		1
Extradition	6		6
False personation	8		8
Falsifying evidence	1		1
Fighting	154	12	166
Forgery	19		19
Fraud	83	3	86
Fugitive from justice	6	1	7
Gambling	24		24
Grand larceny	100	2	102
Having stolen property in possession	11	2	13
Hunting at night	2		2
Indecent exposure	29		29
Insanity	33	5	38
Intend to defraud	7		7
Intoxication	509	4	513
Intoxication and disorderly	691	12	703

Offense.	Male.	Female.	Total.
Intoxication and assault	1		1
Intoxication and violating sanitary regulations	4		4
Intoxication and vagrancy	5		5
Intoxication and loitering	2		2
Keeping disorderly house	1	5	6
Kidnaping	4		4
Lewd and lascivious cohabitation	65	59	124
Loitering	301	4	305
Malicious mischief	54	6	60
Manslaughter	6		6
Mayhem	2		2
Midwifery without a license		5	5
Murder	12		12
Nonsupport	24		24
Obscene and indecent language	29	1	30
Obstructing railroad	6		6
Obtaining money by false pretenses	2		2
Perjury	3		3
Petit larceny	309	20	329
Prostitution		2	2
Rape	3		3
Refusing to assist an officer	3		3
Resisting arrest	5		5
Rioting	15		15
Robbery	10		10
Seduction	1		1
Slander	1		1
Suspicion	10		10
Threats	2		2
Trespass	152	5	157
Unlawful possession of firearms	48		48
Using false weights	2	1	3
Vagrancy	449	2	451
Violating lottery laws	2		2
Violating building regulations	34		34
Violating license regulations	44	3	47
Violating liquor regulations	10	3	13
Violating quarantine regulations	11		11
Violating revenue laws	21	3	24
Violating sanitary regulations	372	42	414
Violating water regulations	2		2
Violating tax regulations	16	1	17
Violating contract-labor laws	4		4
Violating immigration laws	1		1
Writ of ne exeat (debt)	2		2
Total	6,470	477	6,947

TABLE 23.—*Nationality of persons arrested during fiscal year ended June 30, 1910.*

Argentine Republic	4
Austria	10
Belgium	1
Bolivia	5
Chile	55
China	67
Colombia	389
Costa Rica	40
Cuba	30
Denmark	13
St. Thomas	7
Ecuador	19
Egypt	5
France	59
French Guiana	3
Guadaloupe	116
Martinique	365
Great Britain:	
Australia	1
British Guiana	22
Canada	4
England	56
India	12
Ireland	32
Malta	1
Scotland	9
South Africa	7
British West Indies—	
Antigua	168
Barbados	1,569
Bermuda	8
Dominica	12
Fortune Island	45
Grenada	56
Jamaica	1,222
Montserrat	39
Nassau	24
St. Kitts	20
Great Britain—Continued.	
British West Indies—Continued.	
St. Lucia	146
St. Vincent	44
Trinidad	177
Turk's Island	4
Guatemala	5
Germany	35
Greece	92
Haiti	35
Holland	9
Dutch Guiana	6
Dutch West Indies	1
Honduras	11
Italy	100
Japan	5
Mexico	42
Nicaragua	25
Norway	17
Panama	355
Peru	27
Portugal	17
Russia	7
Finland	5
Salvador	10
Santo Domingo	1
Spain	667
Switzerland	1
Sweden	21
Turkey	10
Syria	22
United States	531
Hawaii	1
Porto Rico	7
Venezuela	16
Total	6,947

TABLE 24.—*Arrests, by stations, during the fiscal year ended June 30, 1910.*

	1909.						1910.						Total.
	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	
Ancon	26	33	56	49	26	15	27	40	49	38	31	37	427
Balboa	22	27	22	32	26	52	29	17	19	39	34	38	357
Las Sabanas	3	4	0	0	0	0	0	5	2	0	0	3	17
Corozal	4	6	6	6	18	15	13	9	8	20	13	11	129
Miraflores	11	8	14	14	17	16	18	14	10	7	8	8	145
Pedro Miguel	3	16	4	23	15	26	10	17	29	38	35	26	242
Empire	86	84	102	79	44	83	67	94	120	79	82	75	995
Paraiso	21	28	28	52	14	8	21	18	23	11	21	15	260
Cucaracha	0	0	0	0	0	0	0	0	0	0	0	0	0
Culebra	44	38	48	64	41	52	35	33	44	40	24	30	493
Las Cascadas	24	21	16	14	16	14	11	24	20	12	49	59	280
Gorgona	71	44	42	49	57	59	37	40	24	50	47	49	569
Bas Obispo	20	19	15	16	5	23	17	13	9	14	11	17	179
Matachin	0	0	0	0	0	0	0	9	14	6	13	9	51
San Pablo	10	6	12	10	0	0	0	10	15	16	17	10	106
Tabernilla	27	13	18	27	44	43	31	13	26	13	30	15	300
Frijoles	0	0	0	0	0	0	0	1	3	2	2	0	8
Cristobal	84	80	50	52	42	72	81	52	83	82	95	100	873
Bohio	3	15	17	36	16	7	10	17	19	12	14	18	184
Gatun	59	84	96	70	75	129	110	108	120	121	94	70	1,136
Mount Hope	0	0	0	0	0	0	0	0	7	0	12	9	28
Toro Point	0	0	0	0	0	0	0	0	0	0	1	1	2
Porto Bello	11	9	13	13	8	2	16	22	18	14	24	16	166
Total	529	535	559	606	464	616	533	556	662	614	657	616	6,947

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TABLE 25.—*Occupations of persons arrested during the fiscal year ended June 30, 1910.*

Attorney	1
Agents	9
Bakers	34
Barbers	8
Bartenders	12
Blacksmiths	34
Boilermakers	29
Brakemen	102
Butchers	26
Cab drivers	53
Carpenters	129
Car repairers	8
Calker	1
Checkers	6
Chauffeur	1
Clerks	72
Coal passers	9
Collector	1
Conductors	10
Cabinetmaker	1
Contractors	6
Cooks	53
Cranemen	10
Distillers	2
Draftsman	1
Dentist	1
Dressmakers	5
Domestics	394
Dredgeman	1
Drillmen	13
Electricians	5
Engineers	66
Farmers	209
Firemen	131
Fisherman	1
Flagmen	14
Foremen	144
Goldsmiths	2
Hostlers	12
Hotel keepers	10
Inspectors	5
Iron workers	8
Janitors	47
Laborers	3,866
Laundresses	53
Laundrymen	6
Linemen	2
Machinists	71
Masons	16
Merchants	120
Messengers	22
Ministers	3
Midwife	1
Miners	3
Musicians	2
Missionary	1
No occupation	289
Orderly	1
Oilers	14
Porters	4
Painters	35
Pattern maker	1
Peddlers	95
Pharmacists	5
Prize fighter	1
Pipe fitters	11
Plumbers	5
Policemen	10
Powdermen	10
Printer	1
Physicians	2
Photographer	1
Restaurant keepers	9
Rodmen	2
Sailors	143
Salesmen	5
Saloon keepers	11
Seamstresses	5
Servants	5
Ship's officers	10
Shoemakers	36
Soldiers	54
Stenographer	1
Stewards	13
Storekeepers	14
Seamen	21
Superintendent	1
Switchmen	25
Telephone operator	1
Tailors	50
Teamsters	57
Telegraphers	9
Timekeepers	20
Trainmen	4
Tinsmith	1
Veterinarian	1
Waiters	46
Watchmaker	1
Washerwoman	1
Watchmen	32
Water boys	31
Yardmaster	1
Total	6,947

TABLE 26.—*Crimes committed by prisoners confined in the penitentiary June 30, 1910.*

Arson (night time)	1
Assault	1
Assault with intent to kill	3
Assault with deadly weapon	11
Assault with attempt to commit crime against nature	2
Attempt to commit crime against nature	3
Attempt to defile a female	1
Burglary:	
First degree	4
Second degree	18
Bringing stolen property into Canal Zone	2
Bigamy	1
Cheats	1
Crime against nature	6
Embezzlement	3
False impersonation	1
Falsifying evidence	1
Forgery	13
Grand larceny	41
Horse stealing	1
Manslaughter	10
Murder:	
First degree	3
Second degree	2
Mayhem	1
Offering bribe to police officer	1
Perjury	1
Prize fighting	1
Receiving stolen property	1
Rape	4
Total	138

TABLE 27.—*Occupation of prisoners confined in the penitentiary June 30, 1910.*

Bakers	2	Machinist	1
Bartender	1	Machinist's helper	1
Brakemen	2	Merchant	1
Blacksmiths	3	Messengers	2
Butcher	1	No occupation	7
Carpenters	4	Oilers	2
Clerk	1	Painter	1
Coachmen	2	Sailors	2
Cooks	2	Switch tender	1
Driller	1	Telephone operator	1
Firemen	4	Timekeeper	1
Farmers	7	Tailor	1
Foreman	1	Waiter	1
Interpreter	1	Watchman	1
Janitors	2	Water boy	1
Laborers	79		
Lineman	1	Total	138

TABLE 28.—*Nationality of persons confined in the penitentiary June 30, 1910.*

Chili	4	Great Britain—Continued.	
Colombia	5	British West Indies—Continued.	
Costa Rica	2	Jamaica	25
Cuba	1	Montserrat	1
China	1	St. Lucia	2
Denmark	1	St. Vincent	1
St. Thomas	1	Trinidad	6
France:		Greece	1
French Guiana	1	Haiti	1
Guadeloupe	3	Italy	3
Martinique	10	Nicaragua	1
Great Britain:		Panama	8
Ireland	1	Peru	3
British West Indies—		Spain	11
Antigua	1	Turkey	1
Barbados	34	United States	8
Bermuda	1		
Grenada	1	Total	138

TABLE 29.—*Ages of prisoners confined in penitentiary June 30, 1910.*

Age.	Black.[a]	White.	White American.	Total.
15 to 30 years	85	13	3	101
30 to 40 years	21	6	1	28
40 to 50 years	7	0	2	9
Total	113	19	6	138

[a] Two colored Americans.

Age of youngest prisoner ... years	15
Age of oldest prisoner ... do	50
Able to read and write	92
Unable to read or write	46

TABLE 30.—*Causes of deaths investigated by the coroner during fiscal year ended June 30, 1910.*

Accidental electrocution	7	Landslide	1
Accidental shooting	2	Natural causes	5
Accidental traumatism	24	Railroad accident	45
Apoplexy	1	Stab wounds	2
Concussion of brain	1	Struck by lightning	1
Drowning	37	Suicide	3
Exposure and starvation	1	Unknown	1
Heart disease	2		
Homicide	10	Total	143

TABLE 31.—*Nationality of persons whose deaths were investigated by the coroner during the fiscal year ended June 30, 1910.*

Bulgaria	1
Chile	2
China	1
Colombia	10
Cuba	1
Ecuador	1
France:	
Guadeloupe	1
Martinique	4
Great Britain:	
British West Indies—	
Antigua	2
Barbados	24
Grenada	3
Jamaica	25
St. Kitts	1
St. Lucia	4
Great Britain—Continued.	
British West Indies—Continued.	
St. Vincent	1
Trinidad	3
Turk's Island	1
Italy	3
Mexico	1
Nicaragua	1
Panama	17
Peru	1
Russia	1
Spain	13
United States	18
Unknown	2
Venezuela	1
Total	143

APPENDIX III.—DIVISION OF PUBLIC WORKS.

TABLE 32.—*Consumption of water, collections made, and bills outstanding for water rents in the city of Panama for the fiscal year ended June 30, 1910.*

[Estimated population, 43,733; 168 public hydrants and taps.]

Quarter ending—	Paying connections.	Consumption per quarter.			Daily average consumption.
		Private.	Public hydrants and taps.	Total.	
		Gallons.	*Gallons.*	*Gallons.*	*Gallons.*
Sept. 30, 1909	1,330	64,816,730	21,886,250	86,702,980	952,780
Dec. 31, 1909	1,362	68,867,000	20,457,000	89,324,000	981,582
Mar. 31, 1910	1,377	62,404,500	25,362,150	87,766,650	953,985
June 30, 1910	1,442	63,997,500	32,568,500	96,566,000	1,049,630
Total for year	....	260,085,730	100,273,900	360,359,630	[a] 987,266

Quarter ending—	Amount collected from private consumers.	Amount paid or to be paid by Panama government.[b]	Total revenue as per agreement.	Average consumption per private connection per quarter.	Average private quarterly bill.	Cost per hydrant and public tap per quarter.
				Gallons.		
Sept. 30, 1909	$16,586.45	....	$16,586.45	48,734	$12.47	....
Dec. 31, 1909	17,505.20	....	17,505.20	50,563	12.86	....
Mar. 31, 1910	16,067.50	$339.10	16,406.60	46,046	11.67	$2.02
June 30, 1910	[c] 16,384.00	16.00	16,400.00	44,380	11.36	.09
Total for year	66,543.15	355.10	66,898.25	189,723	48.36	2.11

[a] Daily average.
[b] The Republic of Panama, under an agreement dated September 20, 1907, pays the difference, if any, between the amount collected from private consumers each quarter and $16,400, in lieu of hydrant rental.
[c] Net amount of bills.

TABLE 33.—*Consumption of water, collections made, and bills outstanding for water rents in the city of Colon for the fiscal year ended June 30, 1910.*

[Estimated population, 18,737; 84 public hydrants and taps.]

Quarter ending—	Paying connections, not including Panama R. R. or Isthmian Canal Commission.	Consumption per quarter.					
		Private consumers.	Panama R. R. reservation.	Isthmian Canal Commission hospital and quarantine station.	Public hydrants and taps.	Total.	Average daily consumption.
		Gallons.	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*	*Gallons.*
Sept. 30, 1909	473	37,283,407	9,849,885	3,430,500	9,341,283	59,905,075	658,297
Dec. 31, 1909	492	36,550,500	7,826,340	2,896,000	13,651,233	60,924,073	669,495
Mar. 31, 1910	522	39,437,180	7,948,740	3,917,032	15,543,598	66,846,550	726,593
June 30, 1910	540	38,890,328	8,184,150	4,728,000	20,928,597	72,731,075	790,555
Total for year	....	152,161,415	33,809,115	14,971,532	59,464,711	260,406,773	[a] 711,494

Quarter ending—	Amount collected from private consumers.	Amount collected from Panama R. R. and Isthmian Canal Commission.	Excess of collections over amount guaranteed by the Panama government.[b]	Total revenue per quarter.	Average consumption per private connection per quarter.	Average private quarterly bill.	Cost per hydrant and public tap per quarter.
					Gallons.		
Sept. 30, 1909	$15,038.75	$3,984.30	$1,523.05	$19,023.05	78,823	$31.79	Free.
Dec. 31, 1909	14,785.55	3,217.20	502.75	18,002.75	74,289	30.05	Free.
Mar. 31, 1910	15,891.85	3,559.80	1,951.65	19,451.65	75,550	30.47	Free.
June 30, 1910	[c] 15,634.00	3,873.90	1,982.70	19,507.90	72,019	28.95	Free.
Total for year	61,350.15	14,635.20	5,960.15	75,985.35	300,681	121.26	

[a] Daily average.
[b] The Republic of Panama, under an agreement dated September 20, 1907, pays the difference, if any, between the amount collected from private consumers each quarter and $17,500, in lieu of hydrant rental.
[c] Net amount of bills.

APPENDIX IV.—DIVISION OF SCHOOLS.

TABLE 34.—*Monthly enrollment and average daily attendance.*

	White schools.		Colored schools.	
	Monthly enrollment.	Average daily attendance.	Monthly enrollment.	Average daily attendance.
1909.				
October	745	683.3	1,067	672.2
November	765	644.4	1,061	509.9
December	766	667.9	947	562.6
1910.				
January	819	715.8	1,086	691.1
February	813	711.3	1,169	662.9
March	819	713.6	1,121	610.9
April	829	716.7	1,058	531.0
May	774	664.9	984	462.0
June	728	632.9	886	445.3

TABLE 35.—*Total enrollment for the year, by schools.*

White schools:	
Ancon School	129
Corozal	35
Pedro Miguel	52
Paraiso	33
Culebra	86
Empire	128
Las Cascadas	55
Gorgona	118
Tabernilla	27
White schools—Continued.	
Gatun	90
Cristobal	207
Colon Beach	62
Total	1,022
Total for all colored schools	1,666
Total white and colored	2,688

TABLE 36.—*Enrollment by grades.*

Grade I	836
Grade II	598
Grade III	532
Grade IV	314
Grade V	184
Grade VI	86
Grade VII	57
Grade VIII	30
Grade IX	40
Grade X	8
Grade XI	3
Grade XII	0
Total	2,688

TABLE 37.—*Number of teachers employed.*

	White.	Colored.	Total.
1909.			
October	32	21	53
November	35	21	56
December	36	21	57
1910.			
January	37	21	58
February	37	21	58
March	37	21	58
April	36	21	57
May	36	21	57
June	35	21	56

Sickness of teachers.

	Days.
1909.	
October	13½
November	44
December	11
1910.	
January	38½
February	18
March	49
April	86
May	90
June	44
Total	394

TABLE 38.—*Value of products raised in school gardens.*

	Unit.	Quantity.	Price.	Proceeds.
			Cents.	
Radishes	Pounds	300	10	$30.00
Lettuce				*a* 13.00
Peas				*a* 1.00
Mustard				*a* 4.00
Beans	Pounds	520	16	83.20
Tomatoes	do	1,183	8	94.64
Cucumbers	do	146	5	7.30
Collards	do	146	8	11.68
Okras	Dozen	1,009	5	50.45
Beets	Pounds	15	3	.45
Endive	Heads	200	5	10.00
Brussels sprouts				*a* 2.00
Corn				*a* 12.00
Scalions				*a* 2.50
Sweet potatoes				*a* 2.50
Watermelons		30	25	7.50
Eggplants	Dozen	1		.50
Total				332.72

a Estimated.

Appendix V.—Canal Zone Funds.

Table 39.—*Revenues collected from July 1, 1909, to June 30, 1910.*

On account of—	Administrative districts.				Total.
	Ancon.	Empire.	Gorgona.	Cristobal.	
Animal license	$71.40	$191.40	$119.70	$110.10	$492.60
Aerated waters	867.60	2,724.80	2,089.20	1,521.60	7,203.20
Auctioneers		24.00	7.00	4.00	35.00
Building rentals	2,660.00	1,872.00	463.35		4,995.35
Bowling alleys		65.00			65.00
Burial permits	314.75	314.75	314.75	314.75	1,259.00
Cabs and coaches		12.75	4.25	16.25	33.25
Carts	7.40	218.40	39.60	114.60	380.00
Circuit court collections	1,877.49	1,877.99	1,878.00	1,877.97	7,511.45
District court collections	8,811.50	8,725.05	5,422.59	7,340.55	30,299.69
Dance halls		130.00	70.00	90.00	290.00
Distilling license	682.81	597.14	1,242.38	636.34	3,158.67
Escheated estates	170.02	170.01	170.01	170.00	680.04
Gathering cocoanuts				105.00	105.00
Hucksters		10.80		104.00	114.80
Hunting permits	433.75	437.75	433.75	433.75	1,739.00
Insurance tax	58.58	58.58	58.59	58.59	234.34
Interest	9,216.99	9,216.99	9,216.98	9,216.98	36,867.94
Land rental	2,982.01	7,585.51	9,542.91	2,172.26	22,282.69
Maintenance, miscellaneous, public works (refund)	372.75	372.75	372.75	372.75	1,491.00
Market rental	384.00	2,566.30	902.25	604.00	4,456.55
Merchandise and drugs	1,124.20	4,163.55	3,125.41	1,309.10	9,722.26
Marshal's fees	164.49	164.50	164.53	164.53	658.05
Peddling	1,378.00	3,757.50	2,256.00	2,692.50	10,084.00
Physicians' license	32.50	32.50	32.50	32.50	130.00
Public entertainments	41.50	512.20	157.70	103.50	814.90
Poll tax	244.40	744.40	403.60	312.40	1,734.80
Pound fees	77.50	213.20	123.20	122.20	536.10
Police fines	106.01	106.00	105.99	106.00	424.00
Restaurants	248.20	671.40	402.60	193.00	1,515.20
Retail liquor license		32,640.00	21,600.00	10,800.00	65,040.00
Retail sale of tobacco	849.60	3,736.80	2,532.40	1,965.20	9,084.00
Real estate tax	3,907.54	10,986.42	12,607.94	5,209.06	32,710.96
School tuition, lost or damaged books	73.28	73.28	73.26	73.26	293.08
Services, district prisoners	216.95	216.97	216.97	216.96	867.85
Sale of property	7.65	7.65	259.15	7.65	282.10
Sale of impounded animals	3.75			9.50	13.25
Sale of imported meats	355.45	103.17	2.95	83.64	545.21
Slaughter tax	145.00	10,997.50	4,005.00	348.50	15,496.00
Water tax	1,079.85	5,732.15	3,910.45	2,240.00	12,962.45
Total	38,966.92	112,061.16	84,327.71	51,252.99	286,608.78
Sale of postage stamps					83,847.10
Money-order fees					22,957.35
Total					393,413.23

TABLE 40.—*Expenditures from July 1, 1909, to June 30, 1910.*

On account of—	Administrative districts.				Total.
	Ancon.	Empire.	Gorgona.	Cristobal.	
Public improvements.					
Roads and trails:					
Construction	$40,495.86	$46,618.53	$16,749.55	$87,139.72	$191,003.66
Maintenance	602.11	9,398.97	5,141.67	66.00	15,208.75
Market houses:					
Construction		125.85		2,371.48	2,497.33
Maintenance	12.68	279.25	278.07	116.77	686.77
Operation	454.88	454.89	482.90	469.91	1,862.58
Slaughterhouses:					
Construction		197.82			197.82
Maintenance	67.50	52.99	89.47	14.71	224.67
Operation	327.31	327.32	327.31	327.31	1,309.25
Waterworks and sewers:					
Construction	427.70	8,137.76	1,112.20	15,333.57	25,011.23
Maintenance		1,466.34	416.82	21.00	1,904.16
Maintenance and sanitation, native villages	3,125.00	3,125.00	3,125.00	3,125.00	12,500.00
Street lighting	274.43	192.38	423.88	336.21	1,226.90
Miscellaneous public works:					
Construction	357.62	5,355.28			5,712.90
Maintenance	54.22	817.21	523.64	30.56	1,425.63
Public schools.					
Schoolhouses:					
Construction	20.32	4,154.45	1,466.04	7,236.26	12,877.07
Maintenance	191.03	1,530.57	608.37	485.02	2,814.99
Rental	150.00				150.00
Salaries, superintendent, teachers, and clerks	12,859.17	12,859.20	12,859.23	12,859.22	51,436.82
Janitor service	405.46	806.27	567.59	783.66	2,562.98
Furniture and equipment	469.34	657.00	218.76	579.97	1,925.07
Supplies	1,096.87	1,436.59	984.75	1,396.95	4,915.16
Traveling and miscellaneous expenses	492.52	363.88	97.39	207.52	1,161.31
Maintenance administrative districts.					
Salaries tax collectors	2,932.67	2,932.71	2,932.72	2,932.72	11,730.82
Salaries district judges	4,181.66	4,181.66	4,181.67	4,181.67	16,726.66
Supplies and miscellaneous	629.94	1,478.54	782.27	561.54	3,452.29
Equipment		5.10			5.10
Maintenance Zone charity cases	200.00	200.00	200.00	200.00	800.00
Maintenance district prisoners	3,831.40	4,432.90	5,258.00	1,962.70	15,485.00
	73,659.69	111,588.46	58,827.30	142,739.47	386,814.92
Contingent expenses.					
Gratuity penitentiary prisoners					757.50
Miscellaneous					1,200.70
Postal service.					
Purchase of stamps					29,400.00
Transportation of mails:					
Isthmus					14,950.67
Ocean					17,419.28
Miscellaneous expenses					10,417.19
Transfer to Isthmian Canal Commission as reimbursement in part for salaries paid					35,000.00
Total					495,960.26

TABLE 41.—*Receipts and disbursements from July 1, 1909, to June 30, 1910, by appropriations.*

DR.

July 1, 1909, treasurer's balance:		
Public improvements and schools	$94,987.07	
1908	4,550.52	
1909	14,340.06	
1910	48,298.11	
Miscellaneous and contingent	743.25	
1908	3,795.15	
1909	3,883.65	
1910	9,974.00	
		$180,571.81
Collecting officer's balance:		
Public improvements and schools, 1910	4,471.63	
Audited bills uncollected	24.20	
		4,495.83
Revenues collected July 1, 1909–June 30, 1910	286,608.78	
Collection of advance to Isthmian Canal Commission	2,500.00	
		289,108.78
Total		474,176.42

CR.

Expenditures for fiscal year 1909, paid July, 1909	23,648.30	
Expenditures July 1, 1909–June 30, 1910	388,773.12	
		412,421.42
June 30, 1910, balance available for expenditures		61,755.00
June 30, 1910, balance in treasury:		
Public improvements and schools	43.27	
1908	4,458.73	
1909	15.75	
1910	39,743.82	
Miscellaneous and contingent	743.25	
1908	3,780.15	
1909	1,181.70	
1910	8,172.75	
		58,139.42
Balance of collecting officers:		
Public improvements and schools, 1910	3,565.31	
Transfer escheated estates	50.27	
		3,615.58
Total funds available		61,755.00

POSTAL SERVICE.

DR.

July 1, 1909, balance in treasury:		
Postal receipts, 1910	$12,463.58	
Revenues collected July 1, 1909–June 30, 1910	106,804.45	
		$119,268.03

CR.

Expenditures for fiscal year 1909, paid July, 1909	654.01	
Expenditures July 1, 1909–June 30, 1910	107,187.14	
		107,841.15
June 30, 1910, balance available for expenditures		11,426.88

APPENDIX VI.—BUSINESS TRANSACTED IN THE COURTS OF THE CANAL ZONE DURING THE FISCAL YEAR ENDED JUNE 30, 1910.

TABLE 42.—*Supreme court.*

	Criminal cases.	Civil cases.		Criminal cases.	Civil cases.
Pending July 1, 1909	1	3	Withdrawn	0	1
Filed during year	2	13	Dismissed	0	1
Affirmed	2	4	Habeas corpus proceeding		1
Reversed	1	3	Pending June 30, 1910	0	6

Number of sessions of court	19
Number of attorneys admitted	5

TABLE 43.—*First circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Collections.		
					Fines.	Costs.	Total.
1909.							
Cases pending July 1	2						
July	3	1	2				
August	4	3		2	$25.00	$10.95	$35.95
September	6	5		1	125.00	23.67	148.67
October	4	2		1	53.17	14.47	67.64
November	7	5		2	75.00	18.20	93.20
December	7	2					
1910.							
January	1	4	1	1			
February	7	6			5.00	5.55	10.55
March	5	6			225.00	26.35	251.35
April	9	7			110.00	36.60	146.60
May	9	8	1		250.00		[a] 250.00
June	8	5	1		65.00	19.35	84.35
Total	72	54	5	7	933.17	155.14	1,088.31

[a] Forfeited, $250.

Cases pending June 30, 1910, 6.

CIVIL CASES.

Cases pending July 1, 1909	[b] 5
Cases filed	8
Cases settled	12
Cases pending June 30, 1910	1
Costs	$48.00
Proceeds from marriage licenses, recording fees, notarial fees, and miscellaneous fees	$376.25

TABLE 44.—*Second circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Convicted.	Acquitted.	Dismissed.	Collections.		
					Fines.	Costs.	Total.
1909.							
Cases pending July 1	14						
July	26	10	3	3	$70.00	$37.15	$107.15
August	12	18	1	8	525.00	47.35	[a] 572.35
September	13	11		2	105.00	116.40	221.40
October	8	4			24.00	7.45	31.45
November	11	6	1	4	25.00		25.00
December	20	12	1		170.00	29.05	[a] 199.05
1910.							
January	19	10	1	7	65.00	23.40	88.40
February	23	12	1	4	152.00	41.85	193.85
March	15	18	3	2	15.00		15.00
April	20	10	6	3	165.00	87.80	252.80
May	19	16	5	3	15.00	12.15	27.15
June	20	14	1	5	10.00	30.65	40.65
Total	220	141	23	41	1,341.00	433.25	1,774.25

[a] Includes forfeitures amounting to $500.

Cases pending June 30, 1910, 15.

CIVIL CASES.

Cases pending July 1, 1909	[b] 74
Cases filed	105
Cases settled	138
Cases pending June 30, 1910	[b] 41
Costs	$992.98
Proceeds from marriage licenses, recording fees, notarial fees, and miscellaneous fees	$1,311.95

[b] Including probate cases.

TABLE 45.—*Third circuit court.*

CRIMINAL CASES.

Month.	Cases filed.	Con-victed.	Acquit-ted.	Dis-missed.	Collections.		
					Fines.	Costs.	Total.
1909.							
Cases pending July 1	9						
July	9	8	1	2		$3.60	$3.60
August	5	3	4	3	$25.00	6.85	31.85
September	5	1		4		8.00	8.00
October	3	2					
November	5	2	1			24.00	24.00
December	12	9			20.00	26.00	46.00
1910.							
January	3	7			485.00	25.70	[a] 510.70
February	6	5	1	1		8.00	8.00
March	13	7		1	1.00	11.95	12.95
April	9	4	1	5			
May	7	5	1	2			
June	4	1	2	2			
Total	90	54	11	20	531.00	114.10	645.10

[a] Includes forfeiture of $425.

Cases pending June 30, 1910, 5.

CIVIL CASES.

Cases pending July 1, 1909 (including probate cases)	52
Cases filed	153
Cases settled	151
Cases pending June 30, 1910 (including probate cases)	54
Costs	$220.00
Proceeds from marriage licenses, recording fees, notarial fees, and miscellaneous fees	$1,203.44

TABLE 46.—*District court, district of Ancon.*

CRIMINAL CASES.

Month.	Cases filed.	Con-victed.	Acquit-ted.	Commit-ted to circuit court.	Dis-missed.	Collections.		
						Fines.	Costs.	Total.
1909.								
Pending July 1	0							
July	67	56	6	3	1	$296.00	$71.00	$367.00
August	88	79	5	3	2	563.00	106.25	669.25
September	97	81	7	7	2	548.00	90.50	638.50
October	111	102	7		2	651.00	141.75	792.75
November	93	78	9	6		474.00	96.00	570.00
December	103	76	14	12		373.00	118.50	491.50
1910.								
January	86	80	4	1	2	453.00	97.50	550.50
February	96	81	6	6	1	670.00	120.00	790.60
March	115	98	7	12		873.50	156.00	1,029.50
April	144	121	12	2	9	630.50	135.50	766.00
May	115	97	10	5	2	613.00	134.75	747.75
June	113	88	16	5	2	677.00	174.35	851.35
Total	1,228	1,037	103	62	23	6,822.00	1,442.10	8,264.10

Forfeitures, $350.
Cases pending June 30, 1910, 3.

CIVIL CASES.

Cases pending July 1, 1909	2
Cases filed	100
Cases settled	89
Cases pending June 30, 1910	13
Costs	$187.40

TABLE 47.—*District court, district of Empire.*

CRIMINAL CASES.

Month.	Cases filed.	Con-victed.	Ac-quitted.	Com-mitted to circuit court.	Dis-missed.	Collections.		
						Fines.	Costs.	Total.
1909.								
Pending July 1	0	.....	.....	.....	.....	.....	.....	.....
July	174	121	33	13	6	$473.00	$142.00	$615.00
August	162	113	31	12	7	536.00	159.50	695.50
September	203	166	30	4	3	711.00	206.40	917.40
October	215	172	15	14	13	544.50	158.00	702.50
November	116	93	15	5	4	277.50	82.50	360.00
December	159	123	12	6	7	586.00	154.00	740.00
1910.								
January	132	103	17	7	16	547.50	135.00	682.50
February	171	130	19	22	0	570.50	168.50	739.00
March	216	174	22	10	8	420.00	159.70	579.70
April	139	112	11	6	11	376.00	179.35	555.35
May	166	139	11	10	4	498.00	280.75	778.75
June	192	157	12	12	11	436.00	326.55	762.55
Total	2,045	1,603	228	121	90	5,976.00	2,152.25	8,128.25

Forfeitures, $60.
Cases pending June 30, 1910, 3.

CIVIL CASES.

Cases pending July 1, 1909	5
Cases filed	272
Cases settled	259
Cases pending June 30, 1910	18
Costs	$536.30
Notarial fees	$0.50

TABLE 48.—*District court, district of Gorgona.*

CRIMINAL CASES.

Month.	Cases filed.	Con-victed.	Ac-quitted.	Com-mitted to circuit court.	Dis-missed.	Collections.		
						Fines.	Costs.	Total.
1909.								
Pending July 1	2	.....	.....	.....	.....	.....	.....	.....
July	137	92	29	10	6	$397.50	$120.50	$518.00
August	92	62	12	8	10	321.00	85.25	406.25
September	91	72	12	3	5	319.00	83.65	402.65
October	105	71	26	2	6	203.00	100.50	303.50
November	115	80	13	18	5	306.00	109.50	415.50
December	127	86	26	7	7	323.00	76.00	399.00
1910.								
January	95	66	8	13	8	332.00	100.25	432.25
February	89	61	17	7	4	164.00	75.55	239.55
March	95	69	11	7	8	341.00	106.50	447.50
April	100	68	17	10	5	397.00	100.70	497.70
May	123	81	22	17	3	383.00	87.50	470.50
June	94	63	16	13	3	207.00	69.65	276.65
Total	1,265	871	209	115	70	3,693.50	1,115.55	4,809.05

Forfeitures, $15.
Cases pending June 30, 1910, 0.

CIVIL CASES.

Cases pending July 1, 1909	6
Cases filed	298
Cases settled	295
Cases pending June 30, 1910	9
Costs	$577.74
Notarial fees	$20.50

TABLE 49.—*District court, district of Cristobal.*

CRIMINAL CASES.

Month.	Cases filed.	Con-victed.	Acquit-ted.	Com-mitted to circuit court.	Dis-missed.	Collections.		
						Fines.	Costs.	Total.
1909.								
Pending July 1	3	....	....	....	....	....	....	....
July	152	111	21	4	15	$239.50	$104.50	$344.00
August	178	139	25	2	16	512.00	121.00	633.00
September	155	115	29	1	8	361.50	111.45	472.95
October	156	120	20	2	16	406.00	125.00	531.00
November	129	107	15	3	2	306.00	93.75	399.75
December	209	164	17	17	12	374.50	149.75	524.25
1910.								
January	204	162	12	1	23	463.50	136.75	600.25
February	175	140	22	5	10	408.50	131.25	539.75
March	219	170	29	13	8	291.50	153.85	445.35
April	216	179	16	10	15	462.00	173.00	635.00
May	207	154	28	6	15	446.50	134.50	581.00
June	191	143	38	4	7	532.50	160.50	693.00
Total	2,194	1,704	272	68	147	4,804.00	1,595.30	6,399.30

Forfeitures, $40.
Cases pending June 30, 1910, 3.

CIVIL CASES.

Cases pending July 1, 1909	4
Cases filed	436
Cases settled	412
Cases pending June 30, 1910	28
Costs	$900.75

APPENDIX VII.—LEGISLATION.

No. 1.

EXECUTIVE ORDER.

By authority of the President of the United States it is ordered:

That the authority of the Collector of Revenues under Act No. 24 of the laws of the Canal Zone, entitled "An Act providing for an inexpensive method of Administration upon the Estates of Employees of the Government of the Canal Zone, or of the Isthmian Canal Commission, who are citizens of the United States and who die in the Canal Zone, Isthmus of Panama, leaving estates of small value upon which regular administration is deemed inadvisable," enacted by the Isthmian Canal Commission March 1, 1905, be, and the same is hereby extended to include all estates of the character described in said act as amended by the Executive Order of June 22, 1907, which do not exceed in value the sum of one thousand dollars.

J. M. DICKINSON,
Secretary of War.

WAR DEPARTMENT, *Washington, D. C., July 21, 1909.*

No. 2.

EXECUTIVE ORDER.

Under authority vested in me by law, it is ordered:

That Section 149 of Act No. 14 of the Laws of the Canal Zone is amended to read as follows:

SEC. 149. Every person guilty of murder in the first degree shall suffer death, or if there be extenuating circumstances, confinement in the penitentiary for life; and every person guilty of murder in the second degree is punishable by imprisonment in the penitentiary not less than ten years.

WM. H. TAFT.

THE WHITE HOUSE, *July 30, 1909.*

No. 3.

EXECUTIVE ORDER.

Under authority vested in me by law, it is ordered:

That every convict who is now or who may hereafter be confined in the Canal Zone penitentiary under sentence for a definite time, and who shall have no infraction of the rules and regulations of the penitentiary or laws of the Canal Zone recorded against him, and who performs the duties assigned to him in a faithful, orderly and peaceable manner, shall be entitled to the diminution of time from his sentence as follows: For the first year, one month; for the second year, two months; for the third year, three months; for the fourth year, four months; for the fifth year, five months; for the sixth and each succeeding year, six months; and pro rata for any part of a year, where the sentence is for more or less than a year.

In case any convict shall be guilty of the violation of any of the rules or regulations of the penitentiary or laws of the Canal Zone as above provided, and has become entitled to any diminution of his sentence by the provisions aforesaid, he shall for the first offense forfeit, if he has made so much, two days; for the second offense, four days; for the third offense, eight days; for the fourth offense, sixteen days; and in addition thereto whatever number of days, more than one, that he is in punishment, shall also be forfeited; for more than four offenses, the warden shall have power to deprive him, at his discretion, of any portion or all of the diminution of sentence that he may have earned, but not less than as provided for the fourth offense: *Provided* That the Chief Executive of the Canal Zone shall have the power to restore to any convict any diminution of sentence forfeited by him.

Whenever any convict is or has been committed under several convictions, with separate sentences, they shall be construed as one continuous sentence, in the granting or forfeiting of diminution of sentence.

The warden, in computing the diminution of sentence of any convict now in the penitentiary, shall allow him for the unexpired portion of his sentence, the same as if this order had been in effect at the commencement of his sentence, but shall not allow him for the portion of his sentence already served.

Wm. H. Taft.

The White House, *July 30, 1909.*

No. 4.

EXECUTIVE ORDER.

Under authority vested in me by law, it is ordered:

Section 454 of Act No. 14 of the Laws of the Canal Zone is amended to read as follows:

Sec. 454. Permits to hunt with firearms upon the public lands of the Canal Zone or on the lands of private ownership, but without prejudice to the rights of the owners, may be issued by the Treasurer of the Canal Zone upon application made to him. But every person who shall hunt at night between the hours of sunset and sunrise with the aid or use of a lantern, torch, bonfire, or other artificial light, or who shall hunt by the use of a gun or other firearm intended to be discharged by an animal or bird, by means of a spring or trap or other similar mechanical device, shall be guilty of a misdemeanor.

Wm. H. Taft.

The White House, *September 8, 1909.*

No. 5.

EXECUTIVE ORDER.

Under authority vested in me by law, it is ordered:

Section 1. The Chairman of the Isthmian Canal Commission shall appoint three persons who shall constitute a "Board of Local Inspectors." The members of this Board shall be employees of the Isthmian Canal Commission, or the Panama Railroad Company, or both, and shall perform the duties hereinafter specified without additional compensation.

SEC. 2. The Board of Local Inspectors shall recommend the classification of masters, mates, engineers, and pilots of steam vessels propelled upon the waters within the jurisdiction of the Canal Zone. Upon such recommendation, in writing, the Head of the Department of Civil Administration, Isthmian Canal Commission, shall issue licenses.

SEC. 3. Whenever any person applies to be licensed as master, mate, engineer, or pilot of any steam vessel propelled upon the waters within the jurisdiction of the Canal Zone, the Board of Local Inspectors shall make diligent inquiry as to his character, and shall carefully examine the applicant, as well as the proof he presents in support of his claim; and if, upon full consideration, they are satisfied that his character, habits of life, knowledge, and experience in the duties of master, mate, engineer, or pilot are all such as to authorize the belief that he is a suitable and safe person to be entrusted with the powers and duties of such station, they shall recommend that a license be issued to him, authorizing him to be employed on any vessel propelled upon the waters within the jurisdiction of the Canal Zone, in such duties, for the term of three (3) years; but such license shall be suspended or revoked upon satisfactory proof of negligence, unskilfulness, or intemperance. The Board of Local Inspectors will recommend the assignment of mates or engineers to an appropriate class designated "Chief," "First," or "Second."

SEC. 4. The Isthmian Canal Commission shall not engage for permanent employment upon any of its vessels propelled by steam, any master, mate, or engineer who shall not be duly licensed by the United States, or the Government of the Canal Zone, and who is not a citizen of the United States, unless an American citizen is not available; and all officers at present employed who do not hold United States licenses will be required to qualify before the Board.

SEC. 5. The Government of the Canal Zone may issue licenses as masters, mates, engineers, or pilots to persons who are not citizens of the United States.

SEC. 6. The Executive Order of the Governor of the Canal Zone, dated December 8, 1905, is amended by this order only in as far as it provides for the examination and licensing of pilots.

WM. H. TAFT.

THE WHITE HOUSE, *October 2, 1909.*

No. 6.

EXECUTIVE ORDER.

Under authority vested in me by law, it is ordered:

1. Chapter II of Title XII of Act No. 14, of the Laws of the Canal Zone, is amended by the addition thereto of the following section:

"SECTION 210½. Every person who shall torture, cruelly beat, abuse, wilfully maltreat, or unnecessarily deprive of liberty any child under the age of eighteen, and every person having custody or possession of a child under the age of fourteen who shall expose it in any highway, street, field, house, or other place with intent to abandon it, is guilty of a misdemeanor."

2. Section 423, Chapter XIV, Title XVI, of Act No. 14, of the Laws of the Canal Zone, is amended to read as follows:

"SECTION 423. Every person who shall overdrive, overload, torture, cruelly beat or unjustifiably injure, maim, mutilate or kill or deprive of necessary food, drink or shelter, or work when unfit for labor, any animal whether wild or tame and whether belonging to himself or to another, or who, being the owner or possessor or having charge or custody of a maimed, diseased, disabled or infirm animal shall abandon it, or leave it to die in a street, road or other place, is guilty of a misdemeanor. Any police officer may lawfully destroy or cause to be destroyed any animal found abandoned and not properly cared for, appearing, in the judgment of two reputable persons called by him to view the same in his presence, to be injured or diseased past recovery for any useful purpose."

3. Any duly appointed agent of a regularly organized humane society in the Canal Zone may be commissioned by the proper authorities of the Canal Zone as a special police officer for the enforcement of the provisions of this order and of any other law, regulation or order in force in the Canal Zone for the prevention of cruelty to children and animals, and when so commissioned shall be vested for that purpose with all the authority of a member of the Canal Zone Police force.

WM. H. TAFT.

THE WHITE HOUSE, *October 2, 1909.*

No. 7.

EXECUTIVE ORDER.

By direction of the President, it is ordered:

That the Executive Order of March 12, 1907, effective July 1, 1907, be and the same is hereby amended by the addition of the following:

Provided, That indemnity insurance companies whose business within the Canal Zone consists solely of furnishing fidelity bonds of employees of the United States, which are required by the laws of the Canal Zone, or regulations of the Isthmian Canal Commission, shall hereafter be exempt from liability to pay the annual fee of fifty dollars and the license tax of one and one-half per centum of their premium receipts.

ROBERT SHAW OLIVER,
Acting Secretary of War.

WAR DEPARTMENT,
Washington, D. C., October 15, 1909.

No. 8.

EXECUTIVE ORDER.

Any person who, as principal or agent, shall, with the intent or for the purpose of recruiting on the Canal Zone mechanics, laborers, artisans, or any character of workmen, to go into a foreign country, induce or attempt to induce any person who is working for or is under contract to work for, or who desires to work for, the Isthmian Canal Commission or the Panama Railroad Company, or a contractor of either or both of them, to cease to work for, or break any such contract to work for, or not to begin work for, the Isthmian Canal Commission or the Panama Railroad Company, or a contractor of either or both of them, or to leave the Canal Zone with a view or for the purpose of working in a foreign country, shall be deemed guilty of a misdemeanor and, upon conviction thereof, shall be punished by a fine not exceeding one thousand dollars ($1,000.00) or by imprisonment in the common jail not to exceed six (6) months, or by both such fine and imprisonment, at the discretion of the Court.

WM. H. TAFT.

THE WHITE HOUSE, *November 23, 1909.*

No. 9.

EXECUTIVE ORDER.

By authority of the President of the United States, it is ordered:

That Act 14, enacted by the Isthmian Canal Commission by authority of the President, under date of September 3, 1904, entitled "An Act to establish a penal code for the Canal Zone, Isthmus of Panama," be and the same is hereby amended by adding after paragraph 6 of Section 450 the following:

7. As a member of a rifle, gun or pistol club, organized for the promotion of rifle, gun or pistol practice, a certified copy of whose constitution and by-laws has been approved by the Chief Executive of the Canal Zone and filed with the Collector of Revenues, when going to and from a target range and when engaged in target practice at a target range. For the purposes of this section certificates of membership in such rifle, gun or pistol club shall be issued under regulations approved by the Chief Executive of the Canal Zone.

and Section 456 be and the same is hereby amended as follows:

The license fees for permits issued by the Treasurer under the provisions of this title shall be as follows: For every permit issued to carry a firearm abroad, five dollars ($5.00); for every permit authorizing an overseer or watchman engaged by a private employer, ten dollars ($10.00) for each watchman or overseer so authorized to carry a firearm; for each hunting permit, five dollars ($5.00); provided that no charge shall be made for hunting permits issued to enlisted men of the Marine Corps stationed on the Isthmus of Panama. The Treasurer shall keep a record of all licenses issued by him, with the name and residence of the persons to whom they are issued, and the date and serial number thereof.

J. M. DICKINSON,
Secretary of War.

WAR DEPARTMENT,
Washington, D. C., December 1, 1909.

No. 10.

EXECUTIVE ORDER.

The Isthmian Canal Commission may, from the necessities of sanitation, cause such improvements to be made in the Canal Zone as the construction of streets, roads, and trails, water and sewer systems, and similar sanitary improvements, and may charge such proportion of the cost thereof, not to exceed one-half, to the owners of the property adjacent to, abutting upon, or within the district in which such improvement is necessary and has been made, as may be decided by the Isthmian Canal Commission to be just and equitable.

Due notice of all such improvements shall be given to persons affected thereby together with the estimated assessment, in accordance with rules to be issued by the Isthmian Canal Commission. Any unpaid assessment shall become a lien upon the property affected thereby collectible as provided by law.

Wm. H. Taft.

Washington, *January 26, 1910.*

No. 11.

EXECUTIVE ORDER.

The provisions of the second paragraph of the Executive Order of March 13, 1907, which fix the duties of the district tax collectors of the Canal Zone, shall not require the collection by them of moneys to be paid for liquor licenses under the regulation respecting the sale of intoxicating liquors in the Canal Zone, approved by the Isthmian Canal Commission April 27, 1907; but such moneys shall be collected by the Collector of Revenues or his deputy or assistant.

Wm. H. Taft.

The White House, *April 2, 1910.*

No. 12.

EXECUTIVE ORDER.

By virtue of the authority vested in me I hereby establish the following Order for the Canal Zone:

Article 1. The Counsel and Chief Attorney for the Isthmian Canal Commission shall be legal adviser to the Commission, the Chairman thereof and to the Head of the Department of Civil Administration; he shall submit his opinions in writing when requested by the Commission, the Chairman thereof or the Head of the Department of Civil Administration; he shall have the direction and control of all litigation before the courts of the Canal Zone or the Republic of Panama in which the Commission, or the Government of the Canal Zone or any of its dependencies are interested or involved, and he may appear for them, or either of them, before said courts when he deems it necessary; he shall have the supervision and direction of all prosecutions for offenses against the laws of the Canal Zone, and he may inquire into criminal matters and prosecute the same in person before the courts, when in his opinion it may be necessary to do so.

Article 2. The Counsel and Chief Attorney for the Isthmian Canal Commission, the Prosecuting Attorney, the Assistant Prosecuting Attorney, or other counsel specially designated by the Head of the Department of Civil Administration, shall have equal authority with the judges of the courts of the Canal Zone to issue subpœnas for witnesses in criminal cases, and each of said officers, as well as any judge of any of the courts of the Canal Zone, may examine witnesses under oath in the investigation of offenses against the laws of the Canal Zone.

Article 3. The information in a criminal case may be filed by the Prosecuting Attorney, the Assistant Prosecuting Attorney, or other counsel specially designated by the Head of the Department of Civil Administration, as well as by the Counsel and Chief Attorney for the Isthmian Canal Commission, and it may be verified by any of said officers, and the affidavit shall be sufficient if it states that the information is based upon the sworn testimony of witnesses and that the affiant solemnly believes that there is just cause for the filing of the information.

Article 4. Section 138 of the Code of Criminal Procedure is hereby amended to read as follows:

SECTION 138. When the information is not subscribed and sworn to by the Prosecuting Attorney, or other officer authorized to file informations, it must be set aside by the court in which the defendant is arraigned, upon his motion.

ARTICLE 5. Civil and criminal process issued from any court or tribunal of the Canal Zone may be executed and return thereon made by any peace officer of the Canal Zone.

The following are peace officers: The Marshal and Deputy Marshals of the Supreme Court; the Marshal of each of the Circuit Courts; the Bailiffs of the Supreme and Circuit Courts and all officers and members of the police force of the Canal Zone.

The provisions of this Article are cumulative, and shall not be construed to repeal or modify the existing laws relating to the execution of process and return thereon.

ARTICLE 6. All laws or orders, or parts thereof, in conflict with this Order are hereby repealed.

WM. H. TAFT.

THE WHITE HOUSE, *April 16, 1910.*

No. 13.

ORDINANCE.

Providing for the keeping of registers by hotel, boarding and lodging house keepers and the recording of certain information therein.

Under authority of the order of the President of March 13, 1907, the following ordinance was enacted, to be in force in the Canal Zone on and after the date of its approval by the Secretary of War:

"Every proprietor or manager of any hotel, boarding or lodging house in the Canal Zone shall keep a register of all guests, which register shall clearly show the name, nationality and date of arrival of each guest, the place from whence he came and the date of his departure and destination. Any proprietor or manager failing to keep such register, or any guest failing or refusing to give true information for entry in such register shall be guilty of a misdemeanor."

Enacted by the Isthmian Canal Commission at the 156th Meeting, April 23, 1910.

Approved by the Secretary of War May 12, 1910.

No. 14.

REGULATIONS FOR THE GOVERNMENT OF RIFLE, GUN, OR PISTOL CLUBS IN THE CANAL ZONE APPLYING FOR THE BENEFITS GRANTED IN THE EXECUTIVE ORDER ISSUED BY THE SECRETARY OF WAR, DECEMBER 1, 1909.

ANCON, CANAL ZONE, *January 4, 1910.*

SECTION 1. Every rifle, gun, or pistol club at present organized in the Canal Zone, or that may hereafter be organized in the Canal Zone for the promotion of rifle, gun, or pistol practice, to secure the benefits granted such clubs by the Executive Order of December 1, 1909, shall submit to the Chairman of the Commission, for his approval, a certified copy of its constitution and by-laws and a list of the officers of the club, which, after approval, shall be filed with the Collector of Revenues of the Canal Zone; and shall comply with these regulations and such as may be promulgated hereafter under the provisions of the Executive Order of December 1, 1909.

SECTION 2. The officers of each rifle, gun, or pistol club that has complied with the requirements of the foregoing section shall file with the Collector of Revenues of the Canal Zone a list of the charter members of the club, and from time to time a list of new members received into the organization. These lists shall set forth the full name, age and place of residence on the Isthmus of each member in good standing who is entitled to the exemptions provided for in the Executive Order of December 1, 1909, and, where members are employees of the Isthmian Canal Commission or the Panama Railroad Company, their metal check numbers shall be given.

SECTION 3. The Collector of Revenues shall issue to each member in good standing of a rifle, gun, or pistol club that has complied with the first and second sections of these regulations, a certificate of membership, which certificate shall give the full name of the member, his place of residence on the Isthmus, the name of the rifle, gun, or pistol club of which he is a member, the character of the firearm which the certificate entitles him to carry, and, if he is an employee of the Isthmian Canal Commission or the Panama Railroad Company, his metal check number. The certificate issued by the Collector of Revenues shall exempt the person to whom it is issued from

the payment of the license or tax provided for by the laws of the Canal Zone for carrying loaded firearms in the Canal Zone only when going to and from a target range and while engaged in target practice at a target range.

SECTION 4. Nothing in these regulations shall be construed as granting permission to any member of a rifle, gun, or pistol club to carry a loaded firearm, except as hereinbefore provided, or to hunt with a firearm in the Canal Zone.

SECTION 5. Any member of a rifle, gun, or pistol club to whom has been issued a certificate entitling him to carry a loaded firearm to and from a target range or engage in target practice at a target range, who endeavors to use the certificate of membership as authority to hunt in the Canal Zone or as authority to carry or have a loaded firearm in violation of the laws of the Canal Zone shall, in addition to such punishment as is fixed by the laws of the Canal Zone, for such violation, forfeit his membership certificate and in future be denied the privilege of a certificate of membership in any rifle, gun, or pistol club in the Canal Zone.

H. H. ROUSSEAU,
Acting Head of Department of Civil Administration.

Approved.

GEO. W. GOETHALS,
Chairman of the Commission.

No. 15.

Amendment to paragraph 4, Building Regulations, adopted by the Isthmian Canal Commission at its 155th Meeting, held December 6, 1909, and approved by the Secretary of War January 25, 1910:

"Dwellings not within the limits of surveyed and platted town sites in the Canal Zone will not be permitted to be constructed within less than two hundred feet of each other, and all such dwellings shall comply with existing sanitary regulations for buildings of this character. They shall likewise comply with the regulation prohibiting the erection of native houses closer than 1,000 feet to Isthmian Canal Commission buildings."

APPENDIX VIII.—STEAMBOAT-INSPECTION SERVICE.

TABLE 50.—*Licenses issued by the board of local inspectors during the fiscal year ended June 30, 1910.*[a]

Master licenses:	
Master of steam launches	1
Master of self-propelling barges	19
Master of towboats	10
Master of steam vessels of 100 tons or less, plying between Zone and Republic of Panama ports	1
Master of ladder dredges	14
Master of suction dredges	3
Master of dipper dredges	9
	[b] 57
Engineers' licenses:	
Engineer of launches	6
Chief and second engineers of self-propelling barges	32
Chief and second engineers of towboats	2
Chief and second engineers of all classes dredges	25
	65
Mates' licenses:	
Mate of self-propelling barges	17
Mate of towboats	2
Mate of dredges, all kinds	26
	45
Pilots' licenses:	
Pilot of steam launches	3
Pilot of self-propelling hopper barges	1
Pilot of towboats	23
Pilot of passenger and cargo steamers, any tonnage	68
	95
	262

[a] Board appointed November 12, 1909.
[b] Of the 57 licenses issued to masters, 31 were issued as joint master-pilot licenses.

APPENDIX IX.—DIVISION OF FIRE PROTECTION.

TABLE 51.—*Detailed statement of fires during the fiscal year ended June 30, 1910.*

Town.	Date.	Description.	Owner.	Total value.	Total loss.	Cause of fire.	How extinguished.
	1909.						
Culebra Island	July 5	Tugboat	Isthmian Canal Commission.	$17,500.00		Spontaneous combustion	With pails of water.
Mount Hope	July 16	Crane	do	3,000.00		Hot cinders	With line of hose and fire extinguisher.
Empire	July 17	Frame dwelling	Private	500.00	$245.00	Unknown	With line of hose.
Cristobal	July 21	do	Isthmian Canal Commission.	2,400.00	1.00	Overheated stovepipe	With pails of water.
Culebra	July 22	do	do	3,343.00		Sparks from locomotive	By beating out.
Gorgona	July 24	Steel and wood electric-light plant	do	25,000.00		Defective electric wires	With pails of water.
Gatun	Aug. 3	Frame dwelling	do	2,400.00	25.00	Oil stove ignited curtains	Do.
Colon	Aug. 11					False alarm	
Gatun	Aug. 19	Oil on ground	Isthmian Canal Commission.		50.00	Sparks from locomotive	Allowed to burn out.
Gorgona	Aug. 20	Frame storehouse	do	120,000.00	25.00	Defective electric switch	With line of hose.
Gatun	Aug. 21	Frame waste bin	do	600.00	5.00	Spontaneous combustion	Do.
Gorgona	Aug. 25	Frame planing mill	do	50,000.00	5.00	Breaking of electric wire	With fire extinguisher.
Colon	Aug. 26	Frame dwelling	Private	8,000.00		Explosion of lamp	By Colon fire department.
Do	Aug. 31	Frame hotel	Panama R. R	7,000.00		Boiling over of grease	With fire extinguishers.
Panama	Sept. 1	Stone and wood dwelling	Private			Overturning of candle	By Panama fire department.
Corozal	Sept. 2	Frame oil warehouse	Isthmian Canal Commission.	1,405.00	265.95	Explosion of gasoline	With line of hose.
Culebra	Sept. 7	Railroad ties	do	55,000.00		Sparks from locomotive	With fire extinguisher.
Cristobal	Sept. 13	Frame roundhouse	Panama R. R	35,400.00	30.00	do	With line of hose.
Gorgona	Sept. 15	Frame store	Private	525.00	2.00	Overturning of lamp	Burning articles thrown outside.
Ancon	Sept. 17	Grass				Sparks from locomotive	Stamped out.
Cristobal	Sept. 20	Freight car loaded with lumber	Panama R. R	1,800.00	105.17	do	With line of hose.
Colon	Sept. 21					False alarm	
Do	do	Private railroad car	Panama R. R.	4,000 00	5.00	Defective electric wires	With fire extinguishers.
Mount Hope	Sept. 24	Grass				Sparks from locomotive	Stamped out.
Colon	do	Frame dwelling	Panama R. R.	1,475.00	550.00	Overturning of oil stove	With line of hose.
Gatun	do	Trestle conveyor	Isthmian Canal Commission.			Burning cement barrels	Do.
Do	Sept. 30	Grass				Sparks from locomotive	With pails of water.
Paraiso	do	Steel and wood railroad bridge	Panama R. R.			Hot cinders from engine	Do.
Gorgona	Oct. 2	Frame dwelling	Isthmian Canal Commission.	5,335.00		Grease on stove	With fire extinguisher.
Cristobal	Oct. 11	Frame roundhouse	Panama R. R.	35,400.00	15.00	Sparks from locomotive	Do.
Empire	Oct. 21					False alarm	
Las Cascadas	Oct. 24	Rubbish				Set afire	Allowed to burn out.

Empire	Nov. 2	Frame dwelling	Private	1,500.00	15.00	Overturning of lamp	With pails of water.
Gorgona	Nov. 6	do	Isthmian Canal Commission.	1,950.00		Child playing with matches.	Smothered out.
Gatun	Nov 12	Frame engine cab	do	125.00	5.00	Overturning of locomotive	With fire extinguisher.
Gorgona	Nov. 26	Frame dwelling	Private	60.00	60.00	Burning ants	Total loss.
Empire	Nov. 29					False alarm	
Cristobal	Dec. 2	Frame dwelling	Isthmian Canal Commission.	8,610.00	25.00	Child playing with matches.	With pails of water.
Gorgona	Dec. 4	Frame repair shop	do	2,500.00	1.50	Explosion of wood alcohol	With fire extinguisher.
Do	Dec. 5	Frame erecting shed	do	5,441.00	10.00	Spontaneous combustion	With line of hose.
Do	Dec. 6	Frame store	Private	5,600.00	15.00	Defective stove	Do.
Culebra	Dec. 13					False alarm	
Empire	Dec. 22	Frame dwelling	Isthmian Canal Commission.	6,237.23		Explosion of alcohol lamp	With fire extinguishers.
Miraflores	Dec. 26	Steel and concrete power plant	do			Spontaneous combustion	Do.
Culebra	Dec. 28	Frame Y. M. C. A. building	do			Chimney burning out	Allowed to burn out.
Colon	Dec. 29	Frame storehouse	do	225,000.00		Burning condemned wood alcohol.	With lines of hose.
	1910.						
Tabernilla	Jan. 1	Frame dwelling	do	2,300.00		Candles on Christmas tree	With fire extinguisher.
Miraflores	Jan. 5	Steel and concrete power plant	do		2.00	Spontaneous combustion	With fire extinguishers.
Culebra	Jan. 10	Frame storehouse and office	do	1,100.00	1,100.00	Unknown	Total loss (late alarm).
Gatun	Jan. 11	Frame dwelling	do	2,800.00	20.00	Electric iron	With pails of water.
Ancon	do	Frame hospital ward	do			Chimney burning out	Allowed to burn out.
Paraiso	do	Frame store	Private	2,250.00	1.00	Incendiary	Burning straw thrown off porch.
Empire	Jan. 12	Frame hotel	Isthmian Canal Commission.			Boiling over of grease	With fire extinguisher.
Colon	Jan. 13	Frame laboratory	do	30,000.00		Explosion of alcohol lamp	With fire extinguishers.
Ancon	do	Frame hospital ward	do	7,000.00		Lighted cigarette stub	With pails of water.
Culebra	Jan. 16	Frame dwelling	do			Defective stovepipe	Fire in stove shut down.
Cristobal	Jan. 28					False alarm	
Gorgona	Jan. 30	Dump	Isthmian Canal Commission.			Spontaneous combustion	With line of hose.
Matachin	Feb. 1	Frame dwelling	Private	35.00	25.00	Overturning of candle	With fire extinguishers.
Cristobal	Feb. 2	Scrap lumber	Isthmian Canal Commission.			Unknown	With line of hose.
Gorgona	Feb. 6	Frame dwelling	do	10,077.00	3.00	Leaking oil stove	With pails of water.
Do	Feb. 8	Frame mess hall	do	1,500.00	120.00	Defective stovepipe	Do.
East Balboa	Feb. 10	Frame repair shop	do			Unknown	With fire extinguishers.
Cristobal	Feb. 12	Freight car	Panama R. R.	1,050.00	32.35	Burning rubbish	With line of hose.
Gatun	Feb. 16	Frame Y. M. C. A. building	Isthmian Canal Commission.	26,000.00	3.00	Spontaneous combustion	With pails of water.
Gorgona	Feb. 19	Dead tree				Sparks from locomotive	With fire extinguisher.
Do	do	Dump	Isthmian Canal Commission.			Spontaneous combustion	With line of hose.
Do	do	Frame waste bin	do			do	With pails of water.
Cristobal	Feb. 22	Frame storehouse	Panama R. R.	12,405.00		do	Do.
Gorgona	Feb. 23	Lumber	Isthmian Canal Commission.	504.00		Sparks from locomotive	Stamped out.
Miraflores	do	Oil around pipe line	Private			do	Dirt shoveled around pipe.

TABLE 51.—*Detailed statement of fires during the fiscal year ended June 30, 1910*—Continued.

Town.	Date.	Description.	Owner.	Total value.	Total loss.	Cause of fire.	How extinguished.
	1910.						
Balboa	Feb. 24	Grass				Sparks from locomotive	With line of hose.
Bas Obispo	Feb. 26	Frame rock crusher	Isthmian Canal Commission.	$30,000.00	$4.00	do	Do.
Cristobal	Mar. 1	Rubbish	Panama R. R.			do	Do.
Ancon	Mar. 2	Grass				do	With pails of water.
Paraiso	do	do				do	With line of hose.
Empire	do	Dead tree				Unknown	Do.
Cristobal	Mar. 3	Frame storehouse	Panama R. R.	193.00	5.00	Sparks from loocmotive	Do.
Do	do	Steel and frame crane	Isthmian Canal Commission.	16,000.00		Hot cinders from engine	Do.
Ancon	Mar. 4	Frame hospital ward	do			Lighted cigar stub	With pails of water.
Colon	do	Frame wireless station	United States Government.	27,700.00	30.00	Defective electric wrie	With line of hose and fire extinguishers.
Ancon	Mar. 6	Freight car	Panama R. R.	1,100.00	3.30	Hot cinders from locomotive.	With line of hose.
Gatun	do	Frame dock and stone bins	Isthmian Canal Commission.	12,000.00	25.00	Hot cinders from engine	With line of hose and fire extinguishers.
Cristobal	do	Frame storehouse	Panama R. R.	193.00		Sparks from locomotive	Stamped out.
Juan Grande	Mar. 7	Scrap lumber	Isthmian Canal Commission.			do	With line of hose and fire extinguishers.
Empire	do	Grass, planing-mill yards	do	35,000.00		do	Do.
Cristobal	Mar. 8	Dump				Fire on dump	Allowed to burn out.
Ballamones	do	Frame dwelling	Private	60.00	60.00	Unknown	Total loss.
Tabernilla	Mar. 9	do	Isthmian Canal Commission.	8,550.00		Defective kerosene lamp	Smothered out.
Paraiso	do	Brush				Sparks from locomotive	With line of hose.
Miraflores	Mar. 10	Grass				do	With pails of water.
Cristobal	do	Lumber	Isthmian Canal Commission.	440.00		do	Do.
Paraiso	Mar. 12	Grass near building	do	1,000.00		do	With line of hose.
Balboa	Mar. 14	Scrap lumber	do			Burning grass	Allowed to burn out.
Cristobal	Mar. 15	Freight cars	do	2,554.00		Fire on dump	With line of hose.
Do	do	do		2,000.00		Sparks from locomotive	With pails of water.
Balboa	Mar 18	Grass near oil tanks	Isthmian Canal Commission.	12,000.00		Unknown	Do.
Pedro Miguel	Mar. 19	Dump cars, old	do			do	With line of hose.
Gatun	Mar. 20	Reels of cable and tar paper	do	652.00	129.42	Hot coals left near reels	With pails of water.
Miraflores	Mar. 21	Brush				Sparks from locomotive	With fire extinguishers.
Tabernilla	Mar. 22	Frame shed	Isthmian Canal Commission.	75.00		Hot coals from engine	With line of hose.
Gorgona	do	Dump	do			Spontaneous combustion	Do.
Mount Hope	do					False alarm	
Ancon	do	Frame, ball-park fence	Private	2,638.00	3.00	Sparks from locomotive	With line of hose.

Miraflores	Mar. 23	Trestle	Isthmian Canal Commission.			do	With pails of water.
Juan Grande	do	Scrap lumper	do			do	Do.
Paraiso	do	Dead tree near dwelling	do	1,100.00		do	With fire extinguisher.
Empire	Mar. 24	Creosoted piling	do	2,500.00	150.00	do	With lines of hose.
Culebra	Mar. 31	Frame dwelling	do	2,650.21		Explosion of oil can	By smothering and throwing oil can out.
Porto Bello	Apr. 9	Frame storage bin	do	81,000.00	5.00	Unknown	With line of hose.
Tabernilla	Apr. 11	Frame store	Private	11,000.00		Defective kerosene lamp	With fire extinguisher.
Porto Bello	Apr. 14	Waste near building	Isthmian Canal Commission.			Sparks from locomotive	Do.
Bas Obispo	Apr. 16	Frame repair shop	do			Carelessness with torch	With pails of water.
Ancon	Apr. 20					False alarm	
Empire	Apr. 21	Fuse box	Isthmian Canal Commission.			Defective electric wire	With fire extinguishers.
Ancon	Apr. 23	Rubbish				Burning rubbish	With line of hose.
Balboa	Apr. 25					False alarm	
Gorgona	May 1	Frame public market	Canal Zone government.			Charocal burner	Do.
Do	May 5	Frame foundry	Isthmian Canal Commission.			Explosion of brass furnace	By throwing sand on hot metal.
Cristobal	May 9	Frame dwelling	do			Chimney burning out	With fire extinguisher.
Gorgona	May 14	do	do	10,027.75		Defective oil stove	Do.
Balboa	May 18	Frame mess hall	do	10,000.00	20.00	Overheated stove	Do.
Cristobal	May 21	Frame dwelling	do	8,550.00	20.00	Boiling over of grease	Do.
Colon	do	Frame office building	Panama R. R.	45,225.00		Accidental ignition of gasoline.	By throwing oil can outside.
Empire	do					False alarm	
Cristobal	May 24	Freight cars	Panama R. R.	3,050.00		Fire on dump	With line of hose.
Tabernilla	May 26	Frame restaurant	Private	350.00	15.00	Overheated stove	With line of hose and fire extinguisher.
Empire	May 30	Frame dwelling	do	2,300.00		Boiling over of grease	With pails of water.
Colon	June 12	do	do			Unknown	By Colon Fire Department.
Gorgona	June 20	Scrap lumber	Isthmian Canal Commission.			Burning scrap lumber	With line of hose.
Do	June 28	Dump, near trestle	do	200.00		Spontaneous combustion	Do.
Do	do	do	do	200.00		do	Do.
Miraflores	June 30	Frame storehouse	do	145,000.00	.35	Overturning of lantern	With fire extinguisher.
Total for year				1,209,435.19	3,237.04		

APPENDIX P.

REPORT OF COL. W. C. GORGAS, MEDICAL CORPS, U. S. ARMY, MEMBER OF ISTHMIAN CANAL COMMISSION, CHIEF SANITARY OFFICER, HEAD OF THE DEPARTMENT OF SANITATION.

ISTHMIAN CANAL COMMISSION,
OFFICE OF THE CHIEF SANITARY OFFICER,
Ancon, Canal Zone, July 27, 1910.

SIR: I have the honor to submit herewith the annual report of the sanitary department for the fiscal year ending June 30, 1910.

The improved health conditions shown in the fiscal year report for 1908–9 continue, with the fiscal year covered by this report, as is shown by the following tables:

WHITE EMPLOYEES.

Year.	Average number.	Total deaths.	Annual average per 1,000.
1907–8	12,058	185	15.34
1908–9	12,299	147	11.95
1909–10	11,954	108	9.03
BLACK EMPLOYEES.			
1907–8	30,999	604	19.48
1908–9	31,962	383	11.98
1909–10	38,581	440	11.40
ALL EMPLOYEES.			
1907–8	43,057	789	18.32
1908–9	44,261	530	11.97
1909–10	50,535	548	10.84

The same improvement is shown in the combined population of the cities of Panama, Colon, and the Canal Zone, the latter including in addition to employees the civil population.

Year.	Average population.	Total deaths.	Annual average per 1,000.
1907–8	112,002	3,100	27.67
1908–9	127,362	2,807	22.04
1909–10	144,614	2,735	18.91

Comparative figures for white employees from the United States for the past three fiscal years are:

Year.	Average number.	Deaths, all cases.	Annual average per 1,000.
1907-8	5,035	41	8.14
1908-9	5,126	42	8.19
1909-10	5,573	31	5.56

The comparative figures for all Americans on the Canal Zone, including employees and the members of their families as well as casuals not in any way connected with the work, are:

Year.	Average population.	Total deaths.	Annual average per 1,000.
1907-8	7,040	59	8.38
1908-9	8,105	64	7.89
1909-10	9,198	54	5.87

The number of deaths from violence for all employees for this fiscal year was 174 as against 178 for 1908-9.

Deaths among employees from diseases which might be called tropical and including lobar pneumonia and pulmonary tuberculosis are as follows:

	1907-8.	1908-9.	1909-10.
Dysentery	35	10	13
Malaria	98	47	45
Pneumonia	175	60	77
Black-water fever	13	22	6
Liver abscess	11	8	6
Pulmonary tuberculosis	60	38	51

Of the 22 deaths reported from beriberi, all occurred in the cities of Colon and Panama, among the civil population of the Republic.

Two deaths among employees from pellagra are noted, which is the first time that this disease has been reported in a fiscal year report.

The record of deaths from typhoid fever among employees is for 1907-8—white 4, black 38, total 42; 1908-9—white 2, black 17, total 19; 1909-10—white 1, black 15, total 16.

During the past year and including sick in hospitals, sick camps, and quarters there was a daily average of 23.01 sick out of every 1,000 employed, as against 23.49 for 1908-9 and 23.85 for 1907-8.

The cost of subsistence per patient per day for the year was \$0.259, while the entire cost of treatment per patient per day was \$1.18, and, deducting the revenues received from patients not entitled to free treatment, the net cost per patient per day was \$1.

Respectfully,

W. C. Gorgas,
Chief Sanitary Officer.

Chairman and Chief Engineer
Isthmian Canal Commission,
Culebra, Canal Zone.

VITAL STATISTICS FISCAL YEAR 1909-10.

Deaths of employees of the Isthmian Canal Commission and Panama Railroad Company.

Color.	Average number of employees.	Total number of deaths from—			Annual death rate per 1,000.		
		Disease.	External causes.	All causes.	Disease.	External causes.	All causes.
White	11,954	63	45	108	5.27	3.76	9.03
Colored	38,581	311	129	440	8.06	3.34	11.40
Total	50,535	374	174	548	7.40	3.44	10.84

Deaths in the cities of Panama and Colon and the Canal Zone.

Place.	Population.	Deaths.	Annual average per 1,000.
Panama	43,733	1,178	26.94
Colon	18,737	457	24.39
Canal Zone	82,144	1,100	13.39
Total	144,614	2,735	18.91

NOTE.—The figures relating to the number of employees are compiled from the pay rolls of the different months of the year. The population and deaths as given for the cities of Panama and Colon and the Canal Zone include employees and civil population.

Total admissions of employees to hospitals and sick camps, including those sick in quarters 44,902
Average per 1,000 of admissions of employees to hospitals and sick camps, including those sick in quarters 889

Deaths, by age, color, and sex.

Age.	White.		Colored.		Yellow.		Total.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Under 1 year	89	54	338	278	3	1	430	333
1 to 4 years	12	16	88	76			100	92
5 to 10 years	7	4	25	21			32	25
11 to 20 years	8	2	82	55			90	57
21 to 30 years	61	16	379	147	7		447	163
31 to 40 years	71	11	204	101	9		284	112
41 to 50 years	42	19	163	51	3		208	70
51 to 60 years	23	7	64	38	5		92	45
61 to 70 years	5	7	28	20	7		40	27
71 to 80 years	3	4	12	12	2		17	16
81 to 90 years	1	2	7	6			8	8
91 to 100 years			1	1			1	1
101 to 110 years			1				1	
Unknown	2	1	26	4	3		31	5
Total	324	143	1,418	810	39	1	1,781	954

Deaths by nationality.

Nation.	Employees.	Nonemployees.	Total.
Africa	1		1
Antigua	9	15	24
Bahama Islands	3	1	4
Barbados	167	150	317
Bermuda Islands		1	1
Bolivia	1		1
Bulgaria	1		1
Canada		1	1
Chile		4	4
China		39	39
Colombia	16	118	134
Costa Rica	4	17	21
Cuba	1	7	8
Demerara	1	1	2
Denmark		2	2
Dominica	1	2	3
Dutch West Indies	1	2	3
Ecuador	1	1	2
England	3	5	8
Finland		1	1
Fortune Island	5		5
France		9	9
Germany		1	1
Greece	6		6
Grenada	6	16	22
Guadeloupe	19	9	28
Guatemala		1	1
Guiana, British	1	5	6
Haiti	1	2	3
Holland		1	1
Honduras		4	4
India	1	3	4
Italy	9	7	16
Jamaica	113	442	555
Martinique	30	52	82
Mexico	3	6	9
Montserrat	5	9	14
Nicaragua		5	5
Panama	20	1,066	1,086
Peru	2	3	5
Porto Rico		2	2
Russia		1	1
San Salvador		1	1
St. Kitts	5	2	7
St. Lucia	12	51	63
St. Thomas	1	5	6
St. Vincent	3	4	7
Spain	48	35	83
Syria		2	2
Sweden		1	1
Trinidad	12	15	27
Turks Island	2		2
United States	31	45	76
Uruguay		1	1
Venezuela	1	2	3
West Indies		2	2
Unknown	2	10	12
Total	548	2,187	2,735

Causes of death of employees of the Isthmian Canal Commission and Panama Railroad.

Causes of death.	White.	Colored.	Total.
DISEASE.			
Alcoholism, acute and chronic	1		1
Aneurysm of abdominal aorta (rupture)		1	1
Aneurysm of aorta (rupture)	1		1
Apoplexy	1	1	2
Asphyxia, chloroform		1	1
Cancer of intestines, peritoneum and rectum		1	1
Cancer of stomach	1		1
Cancer of organs not specified		1	1
Cholangitis, supurative	1		1
Cholecystitis, acute gangrenous		1	1
Colitis, acute and chronic		4	4
Congestion and hemorrhage of the brain	2	1	3
Dementia praecox		1	1
Dropsy		1	1
Dysentery	1	12	13
Embolism and thrombosis	1	1	2
Emphysema, pulmonary	1	1	2
Empyema		3	3
Encephalomalacia, acute		2	2
Encephalon, abscess of		1	1
Endocarditis	1		1
Entero-colitis, acute		1	1
Fever:			
Hemoglobinuric	6		6
Malaria	10	35	45
Typhoid	1	15	16
Heart:			
Acute rupture of		1	1
Organic diseases of	2	13	15
Hemorrhage, gastric		1	1
Infection of unknown origin		3	3
Influenza	1	1	2
DISEASE—continued.			
Intestinal obstruction		1	1
Leukemia	1		1
Liver:			
Abscess of	2	4	6
Cyst of	1		1
Cirrhosis of			
Lungs:			
Abscess of	1		1
Edema of	1		1
Gangrene of		1	1
Meningitis:			
Epidemic, cerebralspinal		3	3
Pneumococcic		1	1
Tuberculous		3	3
Simple	1		1
Myelo-malacia		1	1
Myocarditis		2	2
Neck, cellulitis of		1	1
Nephritis:			
Acute		4	4
Chronic	2	34	36
Pellagra	1	1	2
Pericarditis	1	2	3
Peritonitis		6	6
Pneumonia	10	67	77
Psychosis, toxic		1	1
Pyelonephritis	1		1
Pyemia		3	3
Sarcoma of femur		1	1
Senility		1	1
Septicemia and purulent infection	3	4	7
Tetanus		1	1
Tuberculosis:			
Abdominal		2	2
General	1	11	12
Miliary		2	2
Pulmonary	5	46	51

Causes of death of employees of the Isthmian Canal Commission and Panama Railroad.—Continued.

Causes of death.	White.	Colored.	Total.	Causes of death.	White.	Colored.	Total.
DISEASE—continued.				EXTERNAL CAUSES—cont'd.			
Ulcer, duodenal		1	1	Dynamite explosions	1	7	8
Undiagnosed		4	4	Electric shock	2	4	6
Renal calculi	1		1	Homicides	2	4	6
EXTERNAL CAUSES.				Lightning	1		1
				Railroad accidents	24	64	88
				Suicides	2		2
Accidental traumatisms, various	7	28	35	Poisoning by food		1	1
Burns and scalds		2	2	Total	108	440	548
Drowning, accidental	6	19	25				

Deaths of white employees from the United States.

Name.	Division.	Time on Isthmus.	Age.	Cause of death.
JULY, 1909.				
Hague, Joseph	Engineering	2 months	41	Organic disease of heart.
Ryan, John	Mechanical	11 months	33	Pneumonia, lobar.
AUGUST, 1909.				
Coogan, Michael	Engineering	3 years	39	Pyelonephritis.
Green, William B	do	28 months	40	Endocarditis.
Smith, Gordan B	Panama Railroad	20 months	22	Drowning, accidental.
Williams, Edward R	Engineering	4 months	23	Do.
SEPTEMBER, 1909.				
Ball, H. C	Quartermaster's department.	3 years	52	Apoplexy.
Lithgow, A. G	Engineering	4 years	42	Fever, hemoglobinuric.
OCTOBER, 1909.				
Worrall, James C		9 months	25	Edema of lungs.
NOVEMBER, 1909.				
Edwards, Charles	Engineering	8 months	39	Alcoholism.
Hawley, G. I	do	4 years	48	Endocarditis.
Hill, George	do	27 years	59	Pneumonia, broncho.
Snyder, William	do	6 months	44	Accidental trauma (railroad).
DECEMBER, 1909.				
Hennigh, George A	Engineering	34 months	22	Accidental drowning.
JANUARY, 1910.				
Brown, John E	Engineering	7 months	26	Accidental trauma (railroad).
Bork, Fred. A	do	33 months	29	Cerebral hemorrhage.
Thorne, Charles L	do	4 years	29	Suicide (firearm).

Deaths of white employees from the United States—Continued.

FEBRUARY, 1910.

Name.	Division.	Time on Isthmus.	Age.	Cause of death.
Obdrett, Ernest	Engineering	2 years	30	Accidental trauma.
Turner, Robert	do		38	Accidental trauma (dynamite).

MARCH, 1910.

Name.	Division.	Time on Isthmus.	Age.	Cause of death.
Cole, W. R	Engineering	32 months	39	Suicide (firearm).
Gardner, George	do	4 years	51	Dysentery, amebic.
McGurn, H. D	do	32 months	25	Electric shock.
McKenna, L. F	Examiner of accounts	6 months	24	Tuberculosis, pulmonary.

APRIL, 1910.

Name.	Division.	Time on Isthmus.	Age.	Cause of death.
Cottrell, R	Engineering	4 years	30	Tuberculosis, pulmonary.
Fake, L. E	Mechanical	1 month	31	Accidental trauma.
Geary, L. D	Engineering	5 years	53	Septicemia.
Hart, F. W		3 years	38	Liver, abscess of, amebic.

MAY, 1910.

Name.	Division.	Time on Isthmus.	Age.	Cause of death.
Barry, John M	Civil administration.	2½ years	41	Organic disease of heart.
Clark, James F		30 months	24	Accidental trauma (railroad).
Healy, Anna	Panama Railroad	1 year	35	Organic disease of heart.
Howard, Robert E	Examiner of accounts.	16 months	28	Accidental trauma (railroad).

JUNE, 1910.—NONE.

Deaths of white women and children from the United States.

JULY, 1909.

Name.	Time on Isthmus.	Age.	Cause of death.
Hogan, Andrew	5½ months	5½ months	Intestinal obstruction.
Roark, Jane	10 months	10 months	Malaria.

AUGUST, 1909.

Name.	Time on Isthmus.	Age.	Cause of death.
Conner, Olive	17 months	2½ years	Malaria.
Gutberlet (infant)	9 months	9 months	Do.
Humphrey, Harriet A	2½ months	71 years	Senility.
McKay, John	2½ years	2½ years	Pachymeningitis, chronic.

OCTOBER, 1909.

Name.	Time on Isthmus.	Age.	Cause of death.
Tanner, Harold	2 months	7 years	Accidental trauma.

NOVEMBER, 1909.

Name.	Time on Isthmus.	Age.	Cause of death.
Bowers, Agnes	3½ months	3½ months	Enteritis, chronic.
Cook, Nathan, jr	2 years	12 years	Appendicitis.
Purcell, James J	4 months	3 years	Accidental trauma (burns).

Deaths of white women and children from the United States—Continued.

DECEMBER, 1909.

Marsh (infant)	13 days	13 days	Pemphigus.

JANUARY, 1910.

Collins, Mrs. H. S	18 months	21 years	Septicemia, puerperal.
Fox, Mrs. B. J		23 years	Do.
Tucker, Richard B	3 months	3 months	Entero-colitis.
Walker, John		7 years	Meningitis, tuberculous.

FEBRUARY, 1910.

Metcalf, Betty	22 months	22 months	Paralysis, cerebral.
Wood (infant)	3 days	3 days	Hemorrhage, cerebral.

MARCH, 1910.

Clayborn (infant)	1 day	1 day	Asthenia.
Stewart, Agnes, Georgia	17 months	47 years	Convulsions of unknown origin.

APRIL, 1910.—NONE.

MAY, 1910.

Graham, Mrs. S. E	18 months	74 years	Nephritis, chronic.
Patterson, Mrs. J. A	9 months	45 years	Carcinoma of pelvis.

JUNE, 1910.

Lloyd, Mrs. H. M	1 year	22 years	Septicemia.
Russell (infant)	3 days	3 days	Malnutrition.

Death rate among Americans on the Isthmus.

	Average number.	Deaths from—			Annual average per 1,000 from—		
		Disease.	External causes.	All causes.	Disease.	External causes.	All causes.
White employees from the United States	5,573	18	13	31	3.23	2.33	5.56
White women and children from the United States	3,625	21	2	23	5.79	.55	6.34
White employees and their families from the United States	9,198	39	15	54	4.24	1.63	5.87

Causes and places of death of employees and civil population.

Diseases.	Ancon Hospital.	Colon Hospital.	Panama.	Colon.	Zone.	Total.
I. *General diseases.*						
Typhoid fever	13	7	3		2	25
Malaria	2	2	103	17	46	170
Malaria fever:						
Estivo autumnal	34	7	22	4	21	88
Cachexia	1		3		2	6
Hemoglobinuric fever	6		1			7
Whooping cough	1		9			10
Diphtheria			2			2
Influenza	1	1	5		1	8
Miliary fever			1			1
Cholera nostras					2	2
Dysentery	4	8	26		12	50
Amebic	6	4		1		11
Bacillary			1			1
Clinical	9					9
Yellow fever	1					1
Erysipelas			1			1
Purulent infection and septicemia	3	8	2			13
Pyemia	2		1			3
Septicemia	3	2	2		1	8
Pyemia and septicemia, pneumococcic	1					1
Tetanus	1	2	13			16
Pellagra	1	5				6
Beriberi			21	1		22
Tuberculosis of the lungs	37	60	148	22	34	301
Tuberculosis, acute miliary	3	1		1		5
Tuberculous meningitis	2	1	1	2		6
Abdominal tuberculosis	3	1	2	1	2	9
Tuberculosis of bones and joints	1					1
Tuberculosis of the larynx	1		2			3
Disseminated tuberculosis	20	4				24
Rickets			1			1
Syphilis			5	1	1	7
Hereditary					2	2
Gonorrheal ophthalmia			1			1
Cancer and other malignant tumors of the buccal cavity			2			2
Cancer and other malignant tumors of the stomach and liver	2		2		1	5
Cancer and other malignant tumors of the peritoneum, intestines, and rectum	1					1
Cancer and other malignant tumors of the female genital organs	1	1	10			12
Cancer and other malignant tumors of the breast				1		1
Cancer and other malignant tumors of other organs and of organs not specified	1	2	5		1	9
Other tumors (tumors of the female genital organs excepted)	1		2			3
Acute articular rheumatism			6			6
Chronic rheumatism and gout			2			2
Addison's disease			1			1
Anemia, chlorosis	1	2			1	4
Other general diseases				1		1
Alcoholism (acute or chronic)		2	8	1		11
Alcoholism, acute			1	1		2
II. *Diseases of the nervous system and organs of special sense.*						
Simple meningitis	4		17			21
Cerebral spinal fever	2	4		5		11
Pneumococcus meningitis	1	1				2
Lateral sclerosis			1			1
Other diseases of the spinal cord	1		4			5
Cerebral hemorrhage, apoplexy	4		15	5	11	35
Softening of the brain		2	2			4
Paralysis without specified cause	1		3			4
Other forms of mental alienation	7		4			11
Epilepsy	1				2	3
Convulsions (nonpuerperal)	1		2		3	6
Convulsions of infants			2	6	3	11
Chorea			1			1
Hysteria			1			1
Neuritis			1			1
Tumor of the brain		1				1

Causes and places of death of employees and civil population—Continued.

Diseases.	Ancon Hospital.	Colon Hospital.	Panama.	Colon.	Zone.	Total.
III. Diseases of the circulatory system.						
Pericarditis	5				2	7
Acute endocarditis		1	17			18
Malignant endocarditis		1				1
Organic disease of the heart	14	11	31	13	9	78
Angina pectoris			4	2	2	8
Aneurism		1	1		1	3
Arterio-sclerosis	1	1	4			6
Other diseases of the arteries		3	2			5
Embolism and thrombosis	2					2
Varices			1			1
Purpera hemorrhagica	1				1	2
Other hemorrhages; other diseases of the circulatory system	3		4	2	3	12
IV. Diseases of the respiratory system.						
Myiasis of nasal fossæ and sinuses	1					1
Acute bronchitis			29	10	3	42
Chronic bronchitis			7	4		11
Broncho pneumonia	7	3	18	11	17	56
Pneumonia (unqualified)		1	56	15	22	94
Lobar pneumonia	64	24		1	12	101
Pleurisy			5		2	7
Empyema	2	2				4
Pulmonary congestion, pulmonary apoplexy	3		9	1		13
Gangrene of the lungs	1					1
Asthma			2			2
Pulmonary emphysema			1			1
Abscess of lungs		2				2
Other diseases of the respiratory system (tuberculosis excepted)		2	1	1		4
V. Diseases of the digestive system.						
Diseases of the teeth and gums					1	1
Other diseases of the mouth and annexa		1			2	3
Acute gastritis			2	1		3
Chronic gastritis				1		1
Acute indigestion				1		1
Other diseases of the stomach (cancer excepted)			1	2	1	4
Diarrhea and enteritis (under 2 years)	1	2	183	68	47	301
Diarrhea and enteritis (2 years and over)	3		34	11	5	53
Ankylostomiasis		1	1		3	5
Ascariasis					3	3
Other intestinal parasites			1		1	2
Appendicitis and typhlitis	2		1			3
Hernias, intestinal obstructions	1	2	9	1	1	14
Intestinal obstruction		1	4		2	7
Diseases of the anus and fecal fistulas			1			1
Other diseases of the intestines	6		2			8
Duodenal ulcer	1					1
Cirrhosis of the liver	2	1	9	1	2	15
Abscess of liver (unqualified)		2	3			5
Amebic abscess of the liver	8	1				9
Jaundice					1	1
Other diseases of the liver	2			7		9
Other diseases of the spleen	1					1
Simple peritonitis (nonpuerperal)	4	4	6	1	7	22
Other diseases of the digestive system (cancer and tuberculosis excepted)	1	2			2	5
VI. Nonvenereal diseases of the genito-urinary system and annexa.						
Acute nephritis	7	3	7	3	6	26
Bright's disease (chronic nephritis)	40	32	58	6	10	146
Pyelo-nephrosis	2	1				3
Other diseases of the kidney and annexa	1	2			1	4
Calculi of the urinary passages	1					1
Diseases of the bladder			1			1
Cystitis			2	1		3
Other diseases of the urethra, urinary abscess, etc			1			1
Hypertrophy of prostate			1			1
Uterine tumor (noncancerous)	1	1	3			5
Salpingitis and other diseases of the female genital organs	3		1			4

Causes and places of death of employees and civil population—Continued.

Diseases.	Ancon Hospital.	Colon Hospital.	Panama.	Colon.	Zone.	Total.
VII. *The puerperal state.*						
Accidents of pregnancy	1		1		1	3
Abortion			1			1
Puerperal hemorrhage	1	2	1	1	1	6
Other accidents of labor					1	1
Puerperal septicemia	4	4	6	5	3	22
Puerperal albuminuria and convulsions		2	1	2	3	8
Eclampsia	3			1		4
VIII. *Diseases of the skin and of the cellular tissue.*						
Gangrene			1			1
Carbuncle			1			1
Acute abscess	1		1			2
Other diseases of the skin and annexa	1					1
Ulcerating granuloma of the pudenda	1					1
IX. *Diseases of the bones and of the organs of locomotion.*						
Other diseases of the bones (tuberculosis excepted)			1			1
X. *Malformation.*						
Congenital malformations (still births not included)			1	1		2
XI. *Diseases of early infancy.*						
Congenital debility, icterus, and sclerema	2	4	15	21	42	84
Premature birth	1	2	12	6	15	36
Other diseases peculiar to early infancy	2	3	6	3	18	32
Malnutrition	1	1	8	4	18	32
Lack of care			3			3
XII. *Old age.*						
Senility			8		11	19
XIII. *Affections produced by external causes.*						
Suicide by poison				2		2
Suicide by firearms				1	2	3
Suicide by jumping from a high place			1			1
Poisoning by food					1	1
Venemous bites and stings					1	1
Other acute poisonings				1		1
Conflagration	1					1
Burns (conflagration excepted)	5	1	2		10	18
Absorption of deleterious gases (conflagration excepted)		1	1			2
Accidental drowning			2	1	39	42
Traumatism by firearms		1			2	3
Traumatism by fall	1				1	2
Traumatism in mines and quarries	3	1			8	12
Traumatism by machines	2				2	4
Traumatism by other crushings (vehicles, railroads, landslides, etc.)	19	23		1	60	103
Starvation			1		2	3
Lightning					1	1
Electricity (lightning excepted)					6	6
Homicide by firearms				2	3	5
Homicide by cutting or piercing instruments					5	5
Homicide by other means	1				2	3
Fractures (cause not specified)	2	5	7			14
Other external violence	3	6	4	1	12	26
XIV. *Ill-defined diseases.*						
Ill-defined organic diseases			1			1
Sudden death			1			1
Cause of death not specified or ill defined	4	4	27	3	13	51
Infections of undetermined origin	4	1	4			9
Total	439	297	1,109	290	600	2,735
Stillbirths	3		95	52	111	261
Grand total	442	297	1,204	342	711	2,996

NOTE.—The deaths occurring in Ancon and Colon hospitals result from sick, injury, or other cases taken from the cities of Panama and Colon, or from the Canal Zone, and in the table of vital statistics are properly credited to either Panama, Colon, or the Canal Zone.

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission, from all causes, for fiscal year 1909–10.

Diseases.	Discharged.	Died.
I. *General diseases.*		
Typhoid fever	181	15
Relapsing fever	3	
Malaria	2,234	
Malaria fever:		
Estivo autumnal	4,172	34
Tertian	1,152	
Quartan	17	
Mixed	58	1
Undetermined	36	
Clinical	1,453	
Cachexia	14	
Hemoglobinuric fever	45	5
Vaccinia	14	
Measles	29	
Influenza	408	
Dysentery	55	5
Amebic	53	6
Clinical	81	4
Leprosy	6	
Erysipelas	4	
Chicken pox	2	
Mumps	16	
Other epidemic diseases	21	
Purulent infection and septicemia	9	6
Pyemia		1
Septicemia		1
Tetanus		1
Pellagra	1	2
Beriberi	1	
Tuberculosis of the lungs	161	46
Acute miliary tuberculosis		2
Tuberculous meningitis	1	2
Abdominal tuberculosis	4	2
Pott's disease	5	1
Tuberculosis of bones and joints	3	
Tuberculosis of the lymph glands	3	
Tuberculosis of the genito-urinary organs	8	
Tuberculous abscess	3	
Tuberculosis of other organs	15	1
Disseminated tuberculosis		14
Syphilis	89	
(*a*) Primary	4	
(*b*) Secondary	43	
(*c*) Tertiary	71	
(*d*) Period not stated	11	
Soft chancre	304	
Adenitis chancroidal	237	
Gonococcus infection	13	
Gonorrhea	404	
Gonorrheal arthritis	18	
Gonorrheal ophthalmia	3	
Cancer and other malignant tumors of the stomach and liver	1	1
Cancer and other malignant tumors of peritoneum, intestines, rectum	3	1
Cancer and other malignant tumors of the skin	1	
Cancer and other malignant tumors of other organs and of organs not specified	5	2
Tumor of brain	1	
Other tumors (tumors of the female genital organs excepted)	23	
Acute articular rheumatism	21	
Chronic rheumatism and gout	36	
Muscular rheumatism	34	
Diabetes	2	
Addison's disease	1	
Anemia:		
Chlorosis	60	
Primary, pernicious	16	
Other general diseases	6	
Alcoholism:		
Acute or chronic	60	1
Acute	26	
Alcoholic psychosis	3	
Chronic lead poisoning	1	
Other chronic poisonings	1	
II. *Diseases of the nervous system and of the organs of special sense.*		
Simple meningitis	2	2
Cerebral spinal fever		2
Pneumococcus meningitis	1	1
Locomotor ataxia	1	
Other diseases of the spinal cord	6	2

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission, from all causes, for fiscal year 1909–10—Continued.

Diseases.	Discharged.	Died.
II. *Diseases of the nervous system and of the organs of special sense*—Continued.		
Cerebral hemorrhage, apoplexy	8	4
Softening of the brain		1
Paralysis without specified cause	11	
General paralysis of the insane	1	
Other forms of mental alienation	40	1
Epilepsy	11	
Hysteria	5	
Neuralgia	17	
Neuritis	40	
Neurasthenia	78	
Other diseases of the nervous system	170	
Trachoma	2	
Diseases of the eye and its annexa	756	
Diseases of the ear	181	
III. *Diseases of the circulatory system.*		
Pericarditis	8	2
Acute endocarditis	6	
Organic disease of the heart	42	17
Angina pectoris	2	
Aneurism	5	1
Arterio-sclerosis	7	
Other diseases of the arteries	22	1
Embolism, thrombosis	1	1
Hemorrhoids	66	
Varices	13	
Varicocele	23	
Phlebitis	1	
Other diseases of the veins	59	
Lymph adenitis (nonvenereal)	84	
Other diseases of the lymphatic system	163	
Other hemorrhages; other diseases of the circulatory system	16	5
IV. *Diseases of the respiratory system.*		
Adenoid vegetations	3	
Inflammation of accessory nasal sinuses	20	
Myiasis of nasal fossæ and sinuses	13	
Other diseases of the nasal fossæ	180	
Laryngitis	3	
Other diseases of the larynx	12	
Diseases of the thyroid body	1	
Acute bronchitis	299	
Chronic bronchitis	46	
Bronchopneumonia	25	4
Pneumonia (unqualified)	6	
Lobar pneumonia	177	68
Pleurisy	129	4
Empyema	8	2
Pulmonary congestion, pulmonary apoplexy	1	
Gangrene of the lungs	2	2
Asthma	48	
Pulmonary emphysema	24	1
Other diseases of the respiratory system (tuberculosis excepted)	19	1
V. *Diseases of the digestive system.*		
Diseases of the teeth and gums	13	
Stomatitis	1	
Other diseases of the mouth and annexa	55	
Pharyngitis	52	
Follicular tonsilitis	36	
Other diseases of the pharynx	109	
Foreign body in the esophagus	1	
Ulcer of the stomach	9	
Acute gastritis	11	
Chronic gastritis	16	
Acute indigestion	34	
Other diseases of the stomach (cancer excepted)	46	
Diarrhea and enteritis (under 2 years)		1
Diarrhea and enteritis (2 years and over)	154	
Ankylostomiasis	43	
Ascariasis	5	
Tapeworm	2	
Strongyloides	3	
Other intestinal parasites	48	
Appendicitis and typhlitis	147	
Hernias, intestinal obstructions	116	2
Inguinal hernia	94	

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission, from all causes, for fiscal year 1909–10—Continued.

Diseases.	Discharged.	Died.
V. *Diseases of the digestive system*—Continued.		
Other hernias	17	....
Diseases of the anus, and fecal fistula	25	....
Other diseases of the intestines	118	1
Duodenal ulcer	3	1
Cirrhosis of the liver	38	....
Biliary calculi	5	....
Abscess of liver (unqualified)	5	1
Amebic abscess of liver	11	5
Cholecystitis	4	....
Jaundice	14	....
Other diseases of the liver	42	3
Other diseases of the spleen	2	1
Simple peritonitis (nonpuerperal)	2	2
Other diseases of the digestive system (cancer and tuberculosis excepted)	7	....
VI. *Nonvenereal diseases of the genito urinary system and annexa.*		
Acute nephritis	55	5
Bright's diseases (chronic nephritis)	137	31
Movable kidney	1	....
Other diseases of the kidneys and annexa	8	2
Calculi of the urinary passages	6	....
Diseases of the bladder	35	....
Cystitis	19	....
Stricture of the urethra	45	....
Other diseases of the urethra, urinary abscesses, etc	40	....
Acute prostatitis	1	....
Chronic prostatitis	2	....
Abscess of the prostate	1	....
Other diseases of the prostate	22	....
Hematocele	2	....
Hydrocele	31	....
Lymph scrotum and varix	4	....
Other nonvenereal diseases of the male genital organs	227	....
Uterine hemorrhage (nonpuerperal)	1	....
Metritis	2	....
Other diseases of the uterus	3	....
Salpingitis and other diseases of the female genital organs	4	....
VII. *The puerperal state.*		
Normal labor	2	....
Puerperal septicemia	1	....
VIII. *Diseases of the skin and cellular tissue.*		
Gangrene	8	....
Furuncle	124	....
Carbuncle	9	....
Acute abscess	181	1
Phlegmon	1	....
Trichophytosis	1	....
Scabies	5	....
Other diseases of the skin and annexa	304	....
Mycetoma	1	....
Filaria medinensis	1	....
Elephantiasis	3	....
Myiasis of skin	1	....
Dhobie itch	12	....
Ulcer of the skin	67	....
Tropical ulcer	5	....
Ainhum	2	....
Impetigo contagiosa	2	....
IX. *Diseases of the bones and of the organs of locomotion.*		
Mastoid abscess	7	....
Osteomyelitis	2	....
Periostitis	5	....
Other diseases of the bones (tuberculosis excepted)	22	....
Ankylosis	1	....
Arthritis	49	....
Synovitis	26	....
Other diseases of the joints (tuberculosis and rheumatism excepted)	87	....
Amputations	138	3
Other diseases of the organs of locomotion	196	....
X. *Malformations.*		
Congenital malformations (stillbirths not included)	4	....

Table showing discharges and deaths of employees in the hospitals of the Isthmian Canal Commission, from all causes, for fiscal year 1909–10—Continued.

Diseases.	Discharged.	Died.
XIII. *Affections produced by external causes.*		
Poisoning by food	2	......
Venomous bites and stings	1	......
Snake bites	1	......
Other acute poisonings	7	......
Burns (conflagration excepted)	83	3
Absorption of deleterious gases (conflagration excepted)	......	1
Traumatism by firearms	2	......
Traumatism by cutting or piercing instruments	13	......
Traumatism by fall	5	1
Traumatism in mines and quarries	646	6
Traumatism by machines	96	3
Traumatism by other crushings (vehicles, railroads, and landslides, etc.)	251	25
Overexertion	1	......
Starvation	3	......
Insolation	1	......
Heat exhaustion	1	......
Electricity (lightning excepted)	7	......
Dislocations	31	......
Sprains	111	......
Fractures (cause not specified)	418	7
Other external violence	700	8
XIV. *Ill-defined diseases.*		
Ill-defined organic diseases	13	......
Cause of death not specified or ill-defined	72	5
No disease, feigned disease	42	......
Infections of undetermined origin	18	3
Total	20,356	397

Consolidated hospital report.

Hospital.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Ancon Hospital:												
Employees	229	459	7,296	9,211	46	203	4,692	8,967	2,416	45	371	455
Nonemployees	60	54	1,684	1,091	35	130	1,566	904	84	23	59	88
Insane	26	231	48	192	3	22	35	112	6	18	30	271
Total	315	744	9,028	10,494	84	355	6,293	9,983	2,506	86	460	814
Colon Hospital:												
Employees	56	99	2,502	2,480	25	119	1,930	1,968	440	337	163	155
Nonemployees	20	41	626	812	20	131	584	643	12	22	30	57
Total	76	140	3,128	3,292	45	250	2,514	2,611	452	359	193	212
Culebra Hospital:												
Employees	......	......	3	3	....	.....	1	2	2	1	......	......
Nonemployees	......	7	92	215	....	3	80	192	7	18	5	9
Total	......	7	95	218	....	3	81	194	9	19	5	9
Palo Seco Leper Asylum:												
Employees	......	......	......	5	....	.....	......	3	......	1	......	1
Nonemployees	1	25	......	14	....	.....	......	4	......	1	1	34
Total	1	25	......	19	....	.....	......	7	......	2	1	35
Taboga Sanitarium:												
Employees	60	......	2,883	......	....	.....	2,852	......	25	......	66	......
Nonemployees	8	......	699	......	....	.....	685	......	1	......	21	......
Total	68	......	3,582	......	....	.....	3,537	......	26	......	87	......
Grand total:												
Employees	345	558	12,684	11,699	71	322	9,475	10,940	2,883	384	600	611
Nonemployees	89	127	3,101	2,132	55	264	2,915	1,743	104	64	116	188
Insane	26	231	48	192	3	22	35	112	6	18	30	271
Total	460	916	15,833	14,023	129	608	12,425	12,795	2,993	466	746	1,070

Consolidated dispensary report.

Class.	White.	Colored.	Total.
Employees	236,339	257,623	493,962
Nonemployees	59,071	39,632	98,703
Total	295,410	297,255	592,665

Consolidated sick-camp report

Station.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Ancon	8	......	1,165	524	....	....	1,120	512	49	11	4	1
Corozal	......	......	43	131	....	....	26	82	17	49	......	......
Miraflores	6	2	552	610	....	....	432	499	123	111	3	2
Pedro Miguel	4	1	527	711	....	....	400	577	124	129	7	6
Paraiso	2	2	252	371	1	2	214	307	35	60	4	4
Culebra	2	10	467	720	....	1	305	390	162	338	2	1
Empire	2	7	238	644	....	....	194	479	43	166	3	6
Las Cascadas	2	9	508	461	2	3	391	374	112	89	5	4
Bas Obispo	5	7	629	575	....	....	498	484	134	90	2	8
Gorgona	1	3	139	452	....	....	102	341	37	110	1	4
San Pablo	5	4	389	662	....	....	290	501	97	157	7	8
Tabernilla	3	8	323	1,058	....	....	257	824	63	232	6	10
Frijoles	......	......	....	243	....	....	....	174	....	69	......	......
Bohio	......	......	9	93	....	....	2	42	7	51	......	......
Gatun	2	13	1,356	3,689	....	1	781	1,925	564	1,751	13	25
Cristobal	......	6	97	939	....	1	76	665	18	272	3	7
Porto Bello	8	5	363	553	2	1	253	392	112	160	4	5
Nombre de Dios	......	......	13	53	....	....	10	45	2	8	1	......
Total	50	77	7,070	12,489	5	9	5,351	8,613	1,699	3,853	65	91

Consolidated hospital, sick-camp, and sick-in-quarters report.

	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Hospitals	460	916	15,833	14,023	129	608	12,425	12,795	2,993	466	746	1,070
Sick camps	50	77	7,070	12,489	5	9	5,351	8,613	1,699	3,853	65	91
Total	510	993	22,903	26,512	134	617	17,776	21,408	4,692	4,319	811	1,161

	White.	Colored.	Total.
Total admissions to hospitals and sick camps	22,903	26,512	49,415
Number of employees sick in quarters	8,328	1,451	9,779
Total	31,231	27,963	59,194
Less number of patients transferred from sick camps to hospitals, and from hospitals to sanitarium, whose admissions are duplicated in above figures.	4,692	4,319	9,011
Net admissions to hospitals and sick camps, and those sick in quarters	26,539	23,644	50,183

Average number of employees constantly sick in hospitals, sick camps, and quarters.

Hospitals.	White.	Colored.	Total.
Ancon Hospital	276.89	370.51	647.40
Colon Hospital	95.32	148.96	244.28
Culebra Hospital	.06	.21	.27
Palo Seco Leper Asylum	....	.92	.92
Taboga Sanitarium	63.66	....	63.66
Total	435.93	520.60	956.53

	Sick camps.			Sick in quarters.		
	White.	Colored.	Total.	White.	Colored.	Total.
Ancon	7.52	2.56	10.08	2.43	.01	2.44
Balboa	....	....	....	1.70	.28	1.98
Corozal	.23	.66	.89	1.42	.04	1.46
Miraflores	3.26	3.56	6.82	.26	.08	.34
Pedro Miguel	4.60	5.60	10.20	2.14	.04	2.18
Paraiso	2.09	2.64	4.73	1.86	.05	1.91
Culebra	3.78	4.09	7.87	3.32	.93	4.25
Empire	2.44	5.41	7.85	5.07	.13	5.20
Las Cascadas	4.36	4.11	8.47	2.14	.07	2.21
Bas Obispo	5.84	5.74	11.58	1.53	....	1.53
Gorgona	1.06	4.26	5.32	7.11	....	7.11
San Pablo	4.02	6.99	11.01	.41	.03	.44
Tabernilla	2.73	9.58	12.31	.96	.01	.97
Frijoles	....	.95	.95	.25	.30	.55
Bohio	.04	.37	.41	.09	.12	.21
Gatun	8.41	18.31	26.72	5.07	.02	5.09
Cristobal	.91	8.97	9.88	12.34	11.15	23.49
Porto Bello	3.33	4.06	7.39	1.22	....	1.22
Nombre de Dios	.08	.47	.55	.09	.48	.57
Total	54.70	88.33	143.03	49.41	13.74	63.15

Average number of employees constantly sick.

	White.	Colored.	Total.
Hospitals	435.93	520.60	956.53
Sick camps	54.70	88.33	143.03
Sick in quarters	49.41	13.74	63.15
Total	540.04	622.67	1,162.71

Average number of employees constantly sick per 1,000.

	White.	Colored.	Total.
Hospitals	36.47	13.49	18.93
Sick camps	4.58	2.29	2.83
Sick in quarters	4.13	.36	1.25
Total	45.18	16.14	23.01

Subsistence and operating expenses.

SUBSISTENCE EXPENSES.

	Hospitals.	Sick camps.	Total.
Number of days' rations issued to patients	530,951	52,193	583,144
Cost of rations issued to patients	$137,790.46	$13,415.96	$151,206.42
Cost of subsistence per patient per day	$0.260	$0.257	$0.259

OPERATING EXPENSES.

Number of days' relief furnished patients	530,951	52,193	583,144
Cost of operation	$665,018.68	$24,735.77	$689,754.45
Cost per capita per day	$1.25	$0.47	$1.18
Cost of operation with amount received from outside patients deducted	$560,122.41	$24,735.77	$584,858.18
Cost per capita per day with above deduction	$1.05	$0.47	$1.00
Cost of dispensaries	$172,433.66		

Outside patients treated in hospitals, and amounts collected for their treatment.

	Cases treated.	Days' relief.	Amount.
Patients for whom the Republic of Panama pays 75 cents per day	2,173	61,561	$46,170.75
Patients for whom the Canal Zone government pays 30 cents per day	399	10,328	3,098.40
Patients paying 30 cents per day for themselves	1,560	16,900	5,070.00
Patients from the Republic of Panama paying other prices	995	9,822	20,988.60
Patients from the Canal Zone paying other prices	2,675	19,404	28,078.13
Patients from the Canal Zone not paying	2,307	48,395	
Patients from the Republic of Panama not paying	629	9,793	
Total	10,738	176,203	103,405.88

NOTE.—Patients carried from one month to another are considered as separate cases in above table.

Surgical operations performed in hospitals.

	Number.	Died.
Amputations:		
Arm	8	
Forearm	4	
Hand	1	
Hip joint	1	
Thigh	15	5
Leg	20	1
Foot	4	
Digits, multiple	83	
Thigh, double	2	1
Arm and leg	2	2
Operations on bones:		
Craniectomy—		
Decompressive	21	8
Exploratory	3	
Laminectomy	5	3
Ostiectomy	9	
Resection of shoulder	1	
Resection of knee	1	1
Wiring of ractures—		
Simple	20	
Compound	19	
Adenectomy:		
Cervical	27	
Axillary	10	
Inguinal—		
Single	475	
Double	81	
Femoral	19	
Herniotomy:		
Inguinal—		
Single	130	1
Double	111	
Femoral	6	
Ventral	18	
Combined (any two of above)	4	
Strangulated	12	

Surgical operations performed in hospitals—Continued.

	Number.	Died.
Genito-urinary tract:		
Nephrotomy	4	2
Nephrectomy	1	....
Nephropexy	1	....
Perinephritic abscess, drainage of	1	....
Urethrotomy—		
Internal	30	....
External	62	1
Varicocele, radical cure	41	....
Hydrocele—		
Single, radical cure	82	....
Double, radical cure	16	....
Orchidectomy	17	....
Epididymotomy	10	....
Amputation of penis and scrotum	2	....
Curetage, uteri	110	1
Perineoplasty	15	....
Trachelorrhaphy	18	....
Vaginal sections	36	1
Vaginal puncture	3	....
Obstetrical:		
Accouchement, force	1	....
High forceps	1	....
Low orceps	5	....
Version	3	1
Perineorrhaphy	76	....
Thorax:		
Thoracotomy	13	1
Excision of breast	11	....
Excision of breast and axilla	3	....
Rectum:		
Hemorrhoids, radical cure	137	....
Fistula in anus, excision of	20	....
Prolapsus rectum, radical excision	1	....
General:		
Thyroidectomy	2	....
Nerve stretching	2	....
Anuerismorrhaphy	1	....
Varicose veins, excision of	7	....
Tenorrhaphy	2	....
Myorrhaphy	3	....
Excision of surface neoplasms	3	....
Gunshot wound of soft parts, operation for	1	....
Extensive injuries to soft parts, operation for	4	....
Plastic operation for congenital defect	4	....
Plastic operation for severe injuries	13	....
Plastic operation for effects of disease	4	....
Skin graft	40	....
Laparotomy:		
For general peritonitis	9	3
For tuberculous peritonitis	4	2
For intestinal obstruction	5	1
Exploratory	22	4
Castro-enterostomy	1	....
Enterectomy	1	1
Enterorrhaphy	2	....
Appendectomy	185	....
Appendectomy with local peritonitis	18	....
Appendectomy with general peritonitis	11	2
Appendicostomy	3	2
Caecostomy	2	1
Sigmoidopexy	1	....
Cholecystotomy	2	....
Cholecystostomy	5	1
Cholecystectomy	4	1
Choledochotomy	1	....
Abscess of liver:		
Laparo-hepatotomy for	23	6
Thoraco-hepatotomy for	7	3
Splenectomy	1	....
Pan-hysterectomy	1	....
Supravaginal hysterectomy	12	1
Hysteromyomectomy	13	....
Myomectomy	7	....
Salpingectomy—		
Single	19	....
Double	2	....
Salpingo-oophorectomy	16	....
Ovarian cystectomy	4	....
Oophorectomy	5	....
Suspensio-uteri	33	....
Plastic operation for chronic pelvic peritonitis	16	1
For ectopic gestation	4	....

Surgical operations performed in hospitals—Continued.

	Number.	Died.
For trauma:		
General peritonitis	1	1
Hematoperitoneum	3	
Rupture of liver	2	2
Stab wound of abdomen	2	
Major operations, various other	109	4
Minor operations, various other	3,646	4
Total	6,120	69

Operations and work performed in eye, ear, nose, and throat clinics.

Adenectomy	2
Adenectomy and tonsillectomy	37
Adenectomy and tonsillotomy	41
Advancement of internal rectus	2
Amputation of uvula	3
Advancement of external rectus	3
Cataract, discission of	4
Cataract, needling	12
Curetage of middle ear	1
Dacryocystotomy	3
Dilations of lachrymal stricture	7
Drainage of frontal sinus	8
Drainage of maxillary sinus	9
Drainage of sphenoid sinus	2
Enucleation	8
Evisceration	10
Excision of alveolar process	1
Excision of growth under tongue	1
Expression for follicular conjunctivitis	11
Expression for trachoma	3
Extraction of cataract	7
Grattage of eyelids	2
Incision of abscess of nasal septum	2
Incision of alveolar abscess	1
Incision of dacryocyst	4
Incision of peritonsillar abscess	6
Incision of postaural abscess	5
Incision of retropharyngeal abscess	1
Iridectomy	22
Killain's operation—frontal sinus	1
Lachrymal canaliculus incised	1
Mastoidotomy, simple	10
Mastoidotomy, radical	15
Meato-mastoidotomy	2
Ossiculectomy	2
Osteoplastic, nose	3
Paracentesis of cornea	11
Paracentesis of membrana tympani	21
Plastic on ear	4
Plastic on eyelid	16
Plastic on lip	1
Plastic on nose	12
Removal of bullet from jaw	1
Removal of aural polyp	3
Removal of nasal polyp	15
Removal of nasal rhinolith	1
Removal of nasal spur	1
Removal of uvula polyp	1
Removal of necrosed bones	1
Submucous resection of nasal septum	126
Tenotomy	6
Tonsillectomy	41
Tonsillotomy	21
Transplanting operation for pterygium	54
Turbinectomy	7
Various other minor operations	623
Total	1,218
Refractions	2,102
Outside cases treated	12,191
Grand total	15,511

Consolidated ward laboratory report of all hospitals.

Blood examinations	22,648
Estivo autumnal	6,031
Tertian—	
Single	1,990
Double	185
Mixed tertian and estivo autumnal	329
Quartan	183
Lepra bacilla	1
Differential blood counts	1,727
Leucocyte counts	2,432
Red blood counts	210
Red and white blood counts	5
Hemoglobin estimations	875
Filaria	9
Spirilla obermeieri	5
Guaiac and turpentine tests for invisible blood	35
Stool examinations	8,490
Ascaris lumbricoides	445
Uncinaria ova	1,282
Uncinaria worms	201
Tricocephalus dispar	1,096
Strongyloides intestinalis	347
Tenia	12
Tenia saginata	2
Ameba	281
Ameba coli	8
Ameba dysenteria	9
Ciliated monads	332
Bilharzia	13
Pus and blood	683
Stool examinations—Continued.	
Pus and epithelial cells	61
Balantidium coli	5
Tubercular bacilli	10
Lepra bacilli	3
Bacilli coli	1
Urine examinations	31,552
Albumen	9,461
Albumen and casts	5,392
Sugar	78
Pus and blood	877
Gonococci	8
Indican	1
Epithelium	60
Hemoglobin	10
Bile	5
Cylindroids	1
Diazo reactions	26
Microscopical examinations	614
Urea estimations	5
Sputum examinations	2,374
Tubucular bacilli	266
Pneumococci	11
Miscellaneous:	
Examinations of—	
Pleural effusions	8
Spinal fluid	14
Vaginal and urethral discharges	198
Pus, blood, and tissue	355
Various smears and discharges	115
Gastric analyses	27

Ancon Hospital.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	212	370	7,000	6,873	43	159	4,490	6,675	2,317	37	362	372
Panama Railroad employees	17	89	296	2,338	3	44	202	2,292	99	8	9	83
Pay patients	53	32	1,507	677	30	60	1,401	574	81	12	48	63
Charity patients	7	22	177	414	5	70	165	330	3	11	11	25
Insane patients	26	231	48	192	3	22	35	112	6	18	30	271
Total	315	744	9,028	10,494	84	355	6,293	9,983	2,506	86	460	814

	White.	Colored.	Total.
Average number of days' treatment per employee for the year	14.13	14.68	14.43
Average number of employees constantly sick during the year	276.89	370.51	647.40
Number of days' relief furnished patients			369,695
Cost of subsistence per patient per day			$0.234

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	14,455	3,316	15	3,883	7,241
Panama Railroad employees	2,740	180	0	96	2,464
Pay patients	2,269	984	1	498	786
Charity patients	620	108	0	87	425
Insane patients	497	10	0	49	438
Total	20,581	4,598	16	4,613	11,354

Operations.

(See report of all surgical operations.)

Laboratory report.

(See consolidated ward laboratory report.)

Colon Hospital.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	45	65	2,032	1,524	22	74	1,564	1,190	341	209	150	116
Panama Railroad employees	11	34	470	956	3	45	366	778	99	128	13	39
Private pay	11	11	473	387	13	49	446	330	6	0	19	19
Municipal pay	2	3	6	50	1	14	6	34	1	2	0	3
Zone charity	7	27	147	375	6	68	132	279	5	20	11	35
Total	76	140	3,128	3,292	45	250	2,514	2,611	452	359	193	212

	White.	Colored.	Total.
Average number of days' treatment per employee during the year	14.53	22.43	18.50
Average number of employees constantly sick during the year	95.32	148.96	244.28
Number of days' relief furnished patients			120,172
Cost of subsistence per patient per day			$0.249

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Isthmian Canal Commission employees	3,666	973	10	937	1,746
Panama Railroad employees	1,471	272	2	149	1,048
Private pay	882	249	0	221	412
Municipal pay	61	0	0	6	55
Zone charity	556	48	1	101	406
Total	6,636	1,542	13	1,414	3,667

Operations.

(See report of all surgical operations.)

Laboratory report.

(See consolidated ward laboratory report.)

Culebra Hospital.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Employees	....	....	3	3	....	....	1	2	2	1	....	....
Nonemployees	....	7	92	215	....	3	80	192	7	18	5	9
Total	....	7	95	218	....	3	81	194	9	19	5	9

	White.	Colored.	Total.
Average number of days' treatment per employee for the year	7.67	25.33	16.50
Average number of employees constantly sick during the year	.06	.21	.27
Number of days' relief furnished patients	....	....	3,498
Cost of subsistence per patient per day	....	....	$0.252

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	6	1	0	1	4
Nonemployees	314	18	3	74	219
Total	320	19	3	75	223

Operations.

(See report of all surgical operations.)

Laboratory report.

(See consolidated ward laboratory report.)

Palo Seco Leper Asylum.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Employees				5				3		1		1
Pay patients	1	19		7						1	1	25
Charity patients		6		7				4				9
Total	1	25		19				7		2	1	35

	White.	Colored.	Total.
Average number of days' treatment per employee for the year		84.25	84.25
Average number of employees constantly sick during the year		.92	.92
Number of days' relief furnished patients			11,401
Cost of subsistence per patient per day			$0.319

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Employees	5				5
Pay patients	27			1	26
Charity patients	13				13
Total	45			1	44

Taboga Sanitarium.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Employees	60		2,883				2,852		25		66	
Families of employees	8		699				685		1		21	
Total	68		3,582				3,537		26		87	

Average number of days' treatment per employee for the year	8.08
Average number of employees constantly sick during the year	63.66
Number of days' relief furnished patients	26,185
Cost of subsistence per patient per day	$0.67

Nationality.

Class.	Number treated.	Americans.	Other nations.
Employees	2,943	1,970	973
Families of employees	707	681	26
Total	3,650	2,651	999

NOTE.—No colored patients treated at Taboga Sanitarium.

Santo Tomas Hospital.

Class.	Remaining July 1.		Admitted.		Died.		Discharged.		Transferred.		Remaining June 30.	
	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.	White.	Colored.
Pay patients	......	35	......	1,231	......	17	......	1,221	......	......	......	28
Charity patients	......	166	......	4,493	......	307	......	4,090	......	......	......	262
Total	......	201	......	5,724	......	324	......	5,311	......	......	......	290

Average number of days' treatment per patient	15.50
Average number of patients constantly sick	239.22
Number of days' relief furnished patients	87,316
Cost of subsistence per patient per day	$0.317

Nationality.

Class.	Number treated.	Americans.		Other nations.	
		White.	Colored.	White.	Colored.
Pay patients	1,266	....	....	259	1,007
Charity patients	4,659	....	....	865	3,794
Total	5,925	....	....	1,124	4,801

Operations.

	Number.	Died.
Major	666	18
Minor	1,226	....
Total	1,892	18

Dispensary.

Class.	White.	Colored.	Total.
Natives	250	597	847
Foreigners	168	113	281
Total	418	710	1,128

Board of health laboratory.

Bacteriological examinations:	
Municipal water supplies	131
Water from—	
Springs	28
Condensers	262
Tank carts	31
Reservoirs, creeks, and rivers	24
Demijohns	35
Filters	13
Blood cultures	419
Throat cultures (diphtheria suspects)	128
Cultures from autopsies	64
Cultures from eye	6
Stools	541
Urine	529
Sputum	23
Pus	32
Testicle	2
Hydrocele fluid	3
Kneejoint fluid	11
Gall-bladder fluid	3
Spleen pulp	1
Spinal fluid	2
Surgical tissue	1
Bacteriological examinations—Continued.	
Various smears and specimens	59
Milk for tubercular bacilli	1
Soil for bacilli coli	24
Antiseptic for telephone mouthpiece	1
Pleural fluid	1
Cultures from nose and mouth	9
Determinations:	
Carbon dioxide in air of wards	1
Chlorine content in water	15
Specific gravity of metal	1
Examinations:	
Leper suspects	34
Mosquitoes, identification of	2
Postmortems—	
Calves	2
Cows	5
Horses	1
Mules	2
Monkey	1
Rats and fleas	33
Goat	1
Dogs	2
Typhoid fever carrier suspect	1

Board of health laboratory—Continued.

Chemical examinations:	
Alcohol, wood	43
Bloodstains	3
Stomach contents	20
Urine	19
Water—	
For determination of dissolved oxygen	23
Reservoir	58
Various liquids, fluids, etc.	24
Agglutination reactions	217
Autopsies	590
Bodies embalmed	56
Chemical examinations—Continued.	
Hydrophobia, preventative treatment	3
Medico-legal postmortems	6
Sections of tissue prepared—	
Frozen	118
Paraffin	8,210
Surgical pathological tissue and neoplasms reported	131
Vaccine inoculations, antityphoid	54
Vaccine treatment, autogenous	19
Water—	
Microscopical examination of	72
Sanitary analysis of	114

Issue of quinine.

Month.	Kilograms.	Pounds avoirdupois.	Month.	Kilograms.	Pounds avoirdupois.
July	54.68	120.55	March	38.10	84.00
August	87.60	193.12	April	239.60	528.22
September	184.60	406.97	May	29.50	65.03
October	61.68	135.98	June	56.50	124.56
November	46.22	101.90			
December	262.90	579.59	Total	1,145.83	2,526.10
January	61.20	134.92	Average per month	95.49	210.51
February	23.25	51.26			

Sanitation statistics.

CITY OF PANAMA.

Anopheles brigade:		
Ditches cleaned	linear feet	1,647,760
Ditches dug	do	3,800
Weeds and grass cut and removed	square feet	1,475,426
Cesspools cleaned		293
Loads of refuse removed from the city		6,600
Premises cleaned by contract		8
Disinfection brigade:		
Houses disinfected and fumigated for beriberi		9
Houses disinfected and fumigated for diphtheria		5
Houses disinfected and fumigated for hemoglobinuric fever		1
Houses disinfected and fumigated for pernicious fever		37
Houses disinfected and fumigated for tuberculosis		51
Cubic feet disinfected and fumigated		6,070,555
Houses disinfected and fumigated for chickenpox		16
Rooms fumigated and disinfected		1,399
Houses fumigated for yellow fever		5
Material used:		
Crude oil	barrels	1,600
Kerosene oil	gallons	246
Larvacide	do	5,945
Destruction of rats:		
Rats caught and killed		15,049
Average number of rat traps in use daily		435
Inspection of houses and yards:		
Houses and yards inspected		766
Persons notified to keep premises in good condition		869
Warning notices complied with		642
Letters to Alcade requesting enforcement of sanitary rules and regulations		407
New buildings:		
Plans submitted to health officer and approved		408

COLON, CRISTOBAL, MOUNT HOPE.

Medical inspection:	
Cases reported by medical inspectors	94
Cases inspected	94
Cases sent to hospital	85
Water and sewers:	
Connections made during the year	80
Total number of connections made to date	597
Outstanding permits	32
Houses in which extensions were made	32
Houses:	
Plans approved	82
Permits to repair issued	317
Permits to occupy issued	58
Temporary permits to occupy issued	11
Houses in which defective plumbing fixtures were found and reported to the superintendent of public works	1,548

Sanitation statistics—Continued.

COLON, CRISTOBAL, MOUNT HOPE—Continued.

Sanitation of Colon:	
Loads of yard garbage removed	2,434
Average number of cans of garbage removed daily	3,108
Vegetation removed ... acres	660
Streets cleaned ... do	2,612
Private properties cleaned	4,165
Pools oiled ... square yards	103,230
Mosquito-breeding places found	2,917
Dogs killed	35
Horses cremated	12
Water receptacles treated	645,555
Ditches constructed ... linear feet	21,343
Ditches constructed ... cubic yards	6,516
Ditches maintained ... linear feet	228,266
Notices to abate nuisances served	7,847
Nuisances abated	6,546
Buildings inspected	42,898
Rats killed	157
Alleys cleaned	12,999
Streets sprinkled ... acres	276
Crab holes worked	38,200
Colon and Cristobal garbage disposed of at the Ninth street dump.	
Sanitation of Cristobal:	
Pools oiled ... square yards	36,653
Water receptacles treated	76,000
Mosquito-breeding places found	477
Ditches maintained ... linear feet	1,310
Crab holes worked	1,800
Sanitation of Mount Hope:	
Pools oiled ... square yards	127,354
Water receptacles treated	188,609
Ditches maintained ... linear feet	228,777
Crab holes worked	39,200
Mosquito-breeding places found	2,275
Ditches constructed ... linear feet	4,684
Fumigation ... cubic feet	156,400
Mount Hope Cemetery maintained.	
Sanitation of Toro Point:	
Pools oiled ... square yards	35,300
Water receptacles treated	1,690
Mosquito-breeding places found	226
Ditches constructed ... linear feet	3,685
Ditches maintained ... do	5,900
Vegetation removed ... square yards	1,325

Quarantine service.

PORTS OF PANAMA-ANCON AND COLON-CRISTOBAL.

Vessels inspected and passed		1,070
Vessels detained in quarantine		10
Vessels fumigated on arrival		57
Vessels fumigated prior to departure		24
Pieces of baggage disinfected		1,923
Crew inspected		81,675
Passengers inspected		59,951
Total persons inspected		141,626
Persons vaccinated at ports of arrival because of compulsory vaccination law		13,327
Persons vaccinated at ports of departure or en route because of compulsory vaccination law		16,194
Total persons vaccinated		29,521
Persons held in quarantine at the detention stations to complete period of incubation of yellow fever or plague		4,347
Persons held in quarantine on board vessels to complete period of incubation of yellow fever or plague		6,242
Total persons held in quarantine		10,589
Persons landed from foreign ports:		
Cabin	19,124	
Steerage	26,402	
		45,526
Persons embarked for foreign ports:		
Cabin	15,760	
Steerage	14,220	
		29,980
Apparent increase for the year from foreign ports:		
Cabin	3,364	
Steerage	12,182	
		15,546
Persons arriving from coast towns on small craft		26,763
Persons embarked for coast towns on small craft		21,807
Apparent increase for the year from coast towns		4,956
Total persons landed		72,289
Total persons embarked		51,787
Excess over number embarked		20,502
Less number for Pacific ports		1,171
Total apparent increase for the year		19,331
Immigrants recommended for rejection		101
Certificates issued to outgoing passengers		554
Persons refused certificates because of trachoma		46
Bills of health viséed		498

BOCAS DEL TORO.

Vessels inspected and passed	437
Crew inspected	13,657
Passengers inspected	6,274

Personnel report.

[Average number of employees at work during the year.]

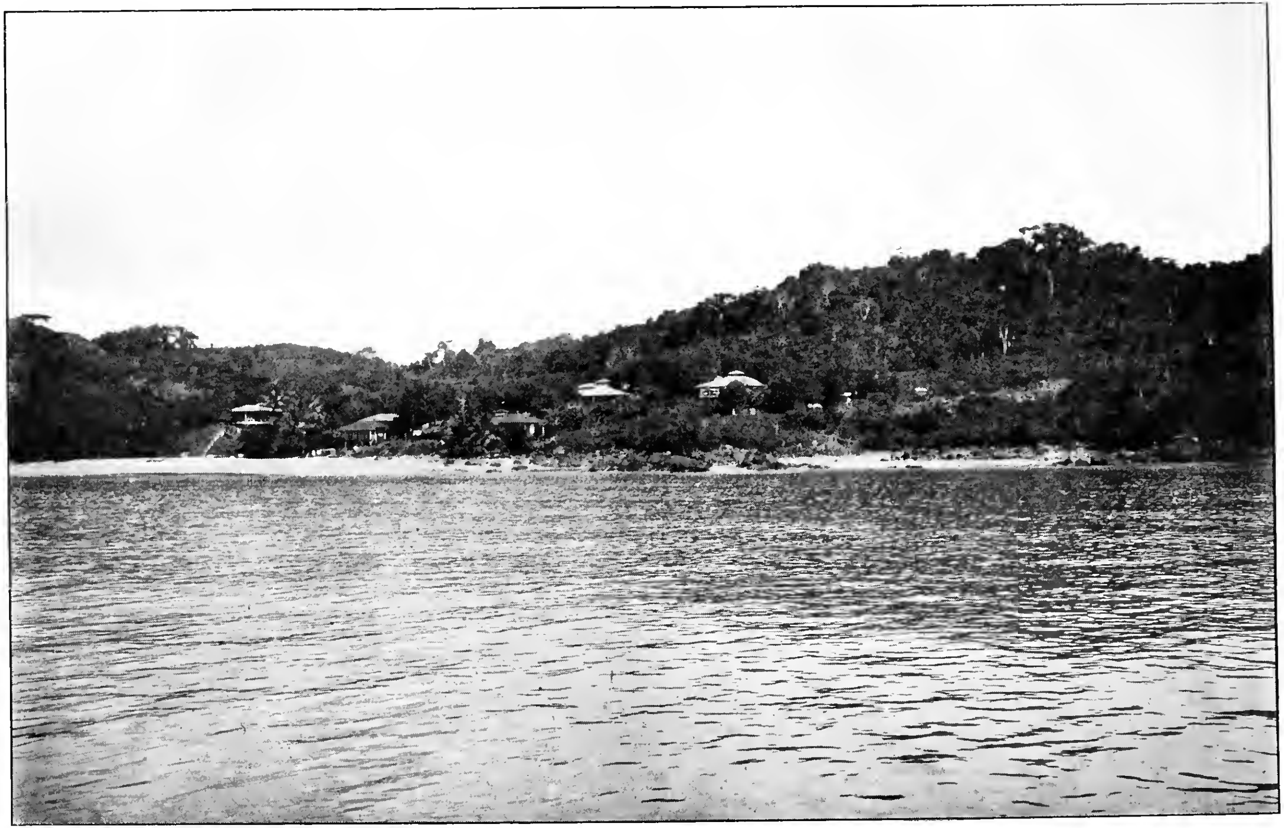
Chief sanitary office	42
Property division	9
Quarantine service	37
Health office:	
Panama	56
Colon	99
Director of hospitals	30
Ancon Hospital	524
Colon Hospital	144
Santo Tomas Hospital	5
Taboga Sanitarium	24
Palo Seco Leper Asylum	13
Zone sanitation	220
Dispensaries:	
Ancon	4
Balboa	4
Bas Obispo	8
Bohio	4
Dispensaries—Continued.	
Corozal	3
Cristobal	9
Culebra	14
Empire	11
Gatun	18
Gorgona	8
Las Cascadas	8
Miraflores	4
Nombre de Dios	4
Paraiso	5
Pedro Miguel	4
Porto Bello	4
San Pablo	4
Tabernilla	4
Total	1,298

Hospital cases of malaria among employees.

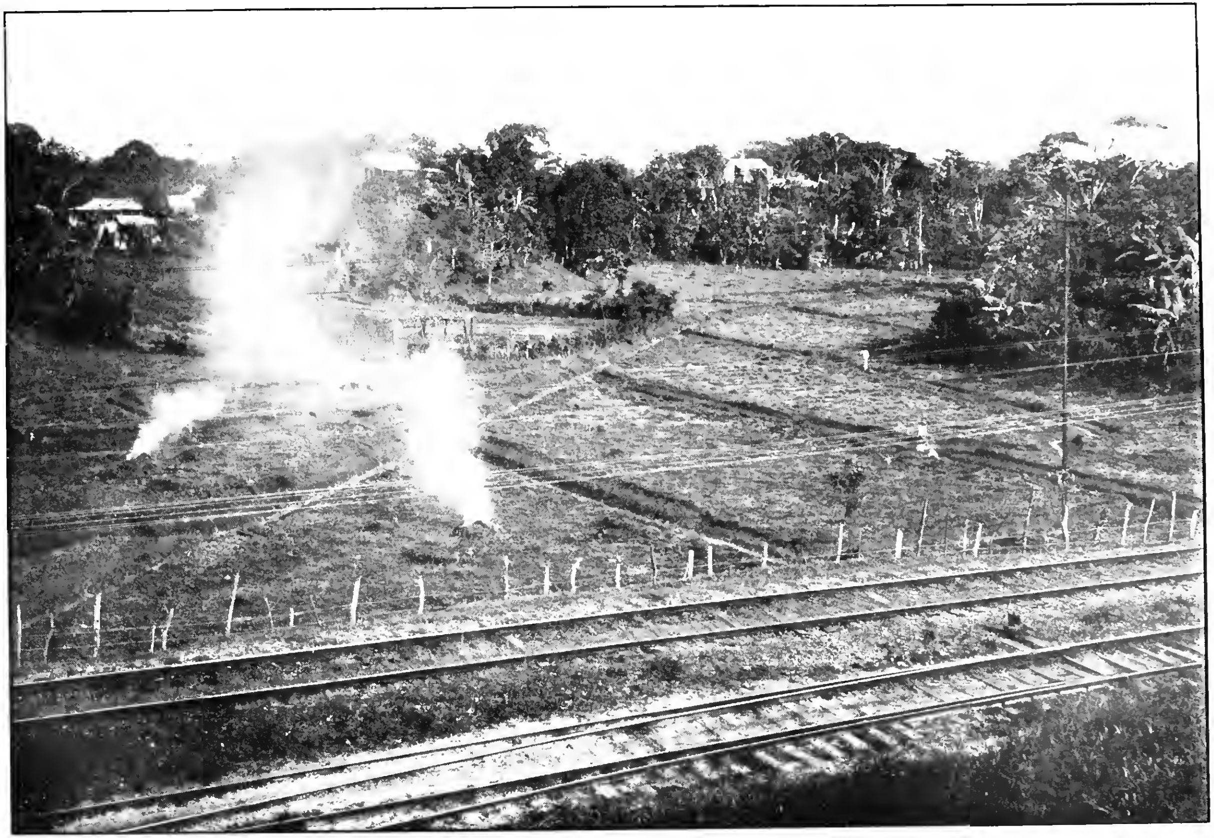
Month.	Discharged.		Died.		Total cases.	Annual average per 1,000 of deaths.	Annual average per 1,000 of cases.	Employees.
	White.	Colored.	White.	Colored.				
July	326	619	1	....	946	0.26	247	45,875
August	296	611	1	1	909	.48	222	49,020
September	329	634	4	3	970	1.72	238	48,888
October	329	740	....	5	1,074	1.18	254	50,641
November	371	485	1	2	859	.68	196	52,643
December	325	443	1	3	772	.99	191	48,544
January	229	247	....	4	480	.96	115	49,961
February	199	159	....	....	358	....	85	50,725
March	263	267	....	2	532	.47	125	51,199
April	248	189	1	....	437	.22	97	54,293
May	268	344	....	1	612	.23	139	52,863
June	629	624	1	7	1,253	1.85	290	51,767
Total	3,812	5,362	10	28	9,202	.75	183	50,535

PLATE 68.

COLON HOSPITAL GROUNDS. NURSES' HALL AND QUARTERS FOR PHYSICIANS.



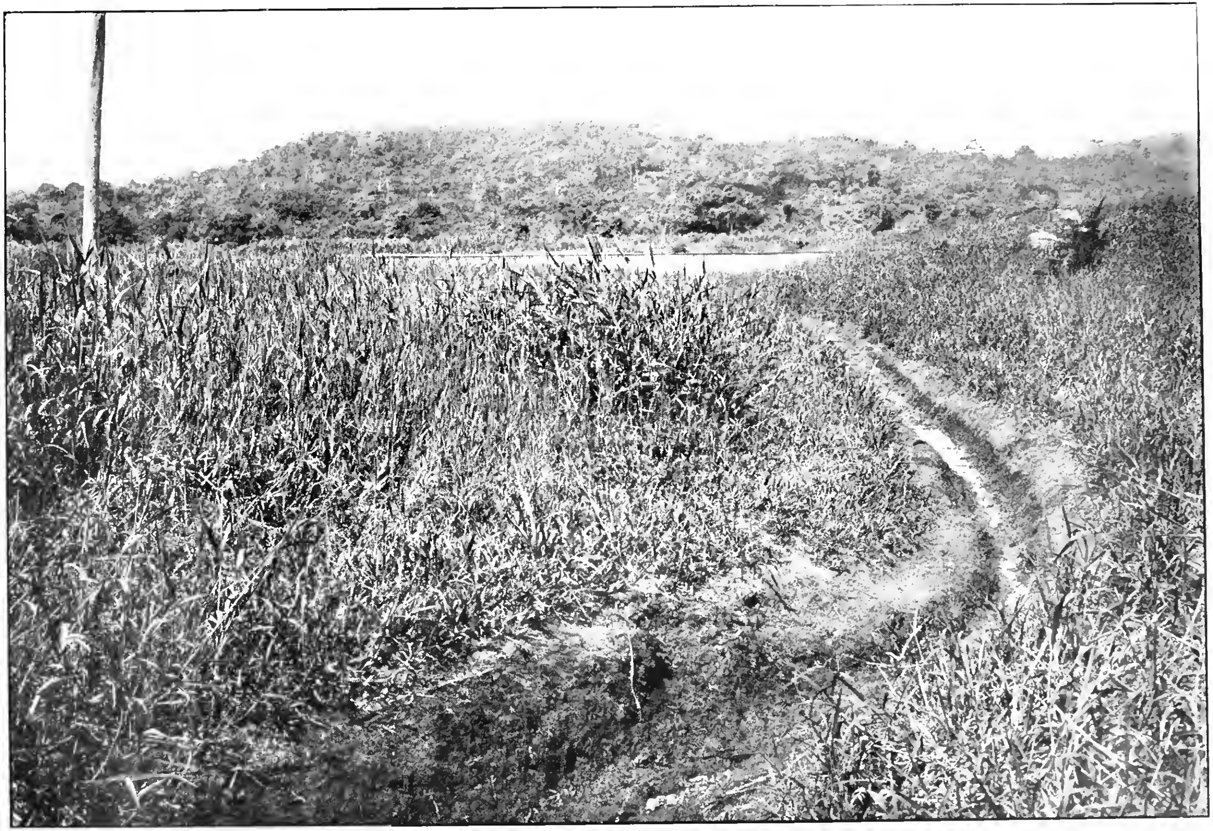
PALO SECO LEPER COLONY FROM THE BAY.



SWAMP NO. 4, MOUNT HOPE, SHOWING ARRANGEMENT OF OPEN EARTH DRAINS FOR SWAMPY AREAS.

APPLICATION OF LARVACIDE BY USE OF KNAPSACK SPRAY.

BURNING GRASS FROM SIDES OF DITCH. CRUDE OIL USED AS FUEL.



CONDITION OF DITCH TWO MONTHS AFTER GRASS BURNING.

DITCH CLEANED BY HAND LABOR, SHOWING CONDITION TWO MONTHS AFTER CLEANING.

APPENDIX Q.

REPORT OF F. C. FREEMAN, SUPERINTENDENT OF CLUB HOUSES.

Isthmian Canal Commission,
Division of Clubhouses,
Culebra, Canal Zone, July 28, 1910.

Sir: I have the honor to submit the following report of the division of clubhouses for the fiscal year ending June 30, 1910:

The work conducted in the clubhouses has been under the supervision of, and carried on by, trained secretaries of the Young Men's Christian Association of North America. It has been the policy of the associations to endeavor to meet the physical, mental, and spiritual needs of every white man and boy in the community on the gold rolls of the Isthmian Canal Commission and Panama Railroad Company.

EQUIPMENT.

At the beginning of the fiscal year 1909–10, four clubhouses were in operation located at Culebra, Empire, Gorgona, and Cristobal. On March 5, 1910, a fifth clubhouse was opened at Gatun, and on April 12, 1910, a sixth was opened at Porto Bello. The Gatun clubhouse is somewhat larger than the original four, it having four bowling alleys instead of two, together with additional rooms for clubs and class work. The Porto Bello clubhouse is of a different and smaller type, having no bowling alleys nor class rooms. The addition of the Gatun and Porto Bello buildings has met the need at two very important points.

ADVISORY COMMITTEE AND EXECUTIVE COUNCILS.

The ownership and control of the property of the commission is represented by a committee of five appointed by the commission and known as the advisory committee. The members of this committee are the following: Col. W. C. Gorgas, chief sanitary officer; Mr. W. W. Warwick, examiner of accounts; Maj. H. A. Brown; Mr. Joseph Bucklin Bishop, secretary of the Isthmian Canal Commission; and Mr. F. C. Freeman, general secretary Young Men's Christian Association.

Executive councils appointed by the International Committee of Young Men's Christian Associations cooperate with the secretaries of their respective clubhouses in managing the activities therein.

MEMBERSHIP.

The privileges of membership have continued to be extended to all white gold employees of the Isthmian Canal Commission and Panama Railroad Company upon the payment of annual dues of $10, semiannual dues of $6, and quarterly dues of $4. About 2,479 different men have availed themselves of the privileges of membership during the past year. The membership has been gradually increasing for the past six months. The largest membership for any month during the year was 1,643, and was reached at the end of June, 1910. The smallest membership for a given month was 1,075, month of November, 1909. The average monthly membership for the year was 1,264. The membership dues for the year aggregated the sum of $13,493.

ACTIVITIES.

The activities during the past year have been similar to those of previous year and the interest shown on the part of the men has, according to monthly statistical reports, exceeded those of past years in most instances.

BOWLING, BILLIARDS, AND POOL.

During the year there were 56,792 games bowled on the bowling alleys with a monthly average of 4,732, while 179,949 games of pool and billiards were played, with a monthly average of 14,996. Seventy-four different tournaments were in progress with 1,184 players enrolled.

VARIOUS CLUBS.

The average monthly enrollment of chess and checker clubs was 46; glee clubs, 12; dramatic and minstrel clubs, 28; camera clubs, 80; Bible clubs, 50, while 274 men were enrolled in educational classes.

LIBRARIES AND READING ROOMS.

It has been the practice to add new books to the libraries from time to time, and in this way they have been kept well supplied with the latest publications. The average monthly enrollment of members taking advantage of the libraries during the past year was 602, while 17,821 books were withdrawn. In conjunction with the library is a reading room where the latest copies of from 60 to 80 of the leading magazines, technical, scientific, and educational periodicals and newspapers are kept on file. The writing tables to be found in the reading rooms have also proven very useful in as much as 62,433 letters were written on them, or an average of 172 per day.

PHYSICAL WORK.

The physical work of the association, has been under the direct charge of trained physical directors. Taking into consideration the fact that the work is conducted in the Tropics, the success has been phenomenal. During the year a monthly average of 184 different men have been using the gymnasiums, while 692 were enrolled in systematic gymnasium work, with a total of 10,475 men using the gymnasiums during the year. This is an increase of 3,303 over the

previous year. In addition to the regular class work, basket ball and indoor baseball have been strong features. Furthermore, men from the Young Men's Christian Associations have trained for and participated in outdoor athletic meets that have been held during the year.

ENTERTAINMENT.

One of the most important features of the work has been the entertainment. In so far as advisable it has been the practice to encourage local entertainments given by the members themselves. These have consisted of dramatics, minstrels, concerts, smokers, debates, and lectures. In addition to these entertainments lyceum attractions have been brought from the States consisting of concert parties, vaudeville troupes, and lecturers. During the past year the Young Men's Christian Association was fortunate in securing the services of the Hon. William Jennings Bryan for a series of six lectures. Efforts along entertainment lines have not been confined to the clubhouses exclusively, as entertainments have been arranged for in several outside towns as well as in the National Theater in Panama. In addition to the above, three opera trains have been run into Panama, thus offering the people of the Zone an opportunity to enjoy grand opera at the National Theater. A total of 194 entertainments were arranged with an attendance of over 38,000. In addition to this 119 functions outside of Association management were given in the clubhouses with an attendance of nearly 17,000.

RELIGIOUS WORK.

It has also been the policy to offer the members the opportunity of attending religious services and of studying the Bible. In an endeavor to strengthen this part of the work the international committee of New York was asked to arrange for a visit by one of its religious-work secretaries. Mr. Charles R. Drum was sent in answer to this request and spent a month on the Canal Zone studying the field, giving addresses, and assisting in organizing this part of the work. Besides the conducting of Bible classes or clubs, mentioned previously in this report, 42 religious meetings were held in the clubhouses with an attendance of nearly 4,000.

BARBER SHOPS AND PRESSING CLUBS.

Barber shops and pressing clubs have been run for the benefit of the members at reasonable rates, and the patronage has been very gratifying. Nonmembers have been allowed to use these privileges at an advanced rate.

REFRESHMENT COUNTERS.

One of the greatest social features of the clubs has been the refreshment counters. All the members and friends can secure ice cream, soft drinks, fresh and malted milk, coffee, sandwiches, cakes, pies, etc. The total receipts from the refreshment counters were $25,025.54, or a daily business of $68.67, which has been conducted on as close a margin as practicable. This is an increase of $2,795.14 over the business of 1908–9.

DORMITORIES.

Although the clubhouses are not provided with regular equipped dormitories, still by the use of cots and mattresses 3,300 beds were furnished free of charge to members and guests during the year.

VISITATION.

The secretaries and committeemen have visited more than 1,600 sick men in the hospitals, and in addition have distributed a large quantity of magazines and newspapers.

COMMITTEES.

It is not possible for secretaries to carry on successful club work alone, and realizing this it has been the policy to develop committees along every possible line. During the past year there was a monthly average of 14 committees and 79 committeemen cooperating with the secretaries in conducting the work.

ATTENDANCE.

The attendance has been carefully estimated each month during the year, and on several occasions an actual count has been taken for periods ranging from ten days to two weeks. As a result the total attendance during the year aggregates over 600,000, or about 1,650 per day.

BOYS' DEPARTMENT.

A very creditable work has been carried on for boys from 10 to 16 years of age. The membership for the year has averaged 65 and the attendance has averaged 47. Besides gymnasium classes and recreative games, 42 outings were arranged for the boys' department.

PRIVILEGES FOR LADIES.

The practice of granting the courtesy of the privileges to the women on two afternoons of each week has been observed as well as their admittance to evening functions. By so doing the clubhouses have endeavored to render a service to the entire communities in which they are located.

FINANCES.

The gross receipts for the year were $64,973.12, or an average of $5,414.42 per month, which is $615.56 per month greater than last year and $933.55 per month greater than two years ago. The year closed with a net balance of $8,156.54 above estimated liabilities, which is $6,987.11 greater than the net balance of one year ago.

Respectfully submitted.

F. C. Freeman,
Superintendent of Clubhouses.

Col. Geo. W. Goethals, *U. S. Army,*
Chairman and Chief Engineer, Culebra, Canal Zone.

APPENDIX R.

REPORT OF CAPT. F. C. BOGGS, CORPS OF ENGINEERS, U. S. ARMY, GENERAL PURCHASING OFFICER AND CHIEF OF THE WASHINGTON OFFICE.

Isthmian Canal Commission,
Washington, D. C., July 15, 1910.

Sir: I have the honor to submit the following report upon the work of this office during the fiscal year ending June 30, 1910:

The office comprises substanially the same divisions as at the close of the preceding fiscal year, all under my charge as general purchasing officer and chief of office of the Isthmian Canal Commission, namely, general office, disbursing office, office of assistant examiner of accounts, appointment, and correspondence and record divisions, and purchasing department. The only change in organization during the past fiscal year has been to combine the work of the record and correspondence divisions under one head, thus resulting in a more economic and better administration of the work.

The total number of appointments made in the United States to skilled positions on the Isthmus has increased slightly during the past year over the number made during the preceding year. There also has been a considerable increase in the number of persons for whom steamer transportation has been arranged between the United States and the Isthmus. However, there has been a reduction in the number of applications for and inquiries concerning employment, although a large number of persons who have no profession or trade and whose services can not be utilized continue to apply for work. This office has experienced some difficulty in securing certain classes of men for work on the canal, particularly mechanics who have specialized along certain lines in railroad work, and other persons who were required to have had technical or special experience along a particular line. During the last twelve months 2,022 persons within the United States have been tendered employment on the Isthmus in grades above that of laborer; 1,287 accepted and were appointed, covering 125 different positions; 5,836 persons, including new appointees, those returning from leave of absence, and members of employees' families, have been provided with transportation from the United States to the Isthmus, and in response to inquiries and applications for employment during this period and in the issuance of appointments 21,437 letters have been written, 3,127 telegrams sent, and 17,044 circulars mailed.

The work of the correspondence and record division as now constituted comprises all general or administrative correspondence and records and also all miscellaneous work not specifically pertaining to other divisions of the office, which, of course, all have their specific records and handle correspondence specially pertaining to their

divisions. The work of the old correspondence and record divisions, now combined in one, is more specifically outlined in the 1907 Annual Report.

The work of the disbursing office has been continued along the lines indicated in the last annual report, and the following shows the volume of business during the past fiscal year:

Claim statement (comparative).

	Fiscal year—	
	1910.	1909.
On hand July 1	30	204
Received July 1 to June 30	14,844	12,154
Total	14,874	12,358
Passed for settlement July 1 to June 30	14,762	12,328
On hand June 30	112	30

From the above it will be noted that the number of claims settled during the fiscal year 1910 exceeded by nearly 19 per cent the number settled in the fiscal year 1909.

Financial statement.

On hand July 1, 1909		$1,761,388.40
Receipts:		
From United States Treasury	$9,990,451.00	
Liquidated damages	36,298.71	
Cash discounts	1,535.65	
Miscellaneous collections	287,732.60	
		10,316,017.96
		12,077,406.36
Disbursements:		
Claims paid	$10,386,340.81	
Deposits to "miscellaneous receipts"	788,583.73	
Repayments to appropriations	21,140.89	
		$11,196,065.43
Balance on hand June 30, 1910		881,340.93
		12,077,406.36

Claims aggregating $104,715.63, which were examined in the disbursing office and settled by the Auditor for the War Department either by direct or transfer settlements, are not included in the above statement.

The assistant examiner of accounts has continued the work of examining the vouchers paid by the disbursing officer, and verifying monthly the cash and net balances appearing on his accounts current. The expenditures have been classified, the annual inventory of property in the United States taken, and the work incident to claims of injured employees arising under the act of May 30, 1908, has been handled by his office. The work involved in the preparation of commission contracts and bonds, and the legal work appertaining thereto, has been performed by the assistant examiner in the same manner as at the close of the last fiscal year.

The purchasing department, under direct supervision of the general purchasing officer, with headquarters in Washington, D. C., and with an assistant purchasing officer located at New York, and assistant

purchasing agents at New Orleans and San Francisco, is charged with the purchasing of and preparation of contracts for supplies, machinery, and plant, including the equipment and material for the permanent work on the Isthmus.

The method of purchasing by circular invitation for bids as described in previous annual reports of the commission, has been continued. The system of purchase under annual contract, which was instituted in 1909, was found to produce satisfactory results during the past fiscal year, and will be continued for the fiscal year 1911, annual contracts having already been entered into covering the year's supply of dynamite, railroad ties, and other principal staple items used in connection with the construction of the canal.

The inspection of material and supplies has been handled by a force of inspectors regularly employed by the commission, with the assistance of the officers of the Corps of Engineers, U. S. Army, situated throughout the country, who are called on to make such inspections as can be most conveniently handled by their offices. Substantial assistance has also been rendered the commission in its purchasing and inspection by the Medical, Quartermaster, Subsistence, and Ordnance departments of the U. S. Army; the technologic branch of the United States Geological Survey; Bureau of Chemistry, Department of Agriculture; United States navy-yard laboratories, and Bureau of Standards, Department of Commerce and Labor.

The total amount of purchase orders placed during the fiscal year ended June 30, 1910, was $16,107,350.34, the most important of these purchases being castings, structural material, and valves for use in the locks, amounting to $847,000, and the mitering lock gates, to be manufactured in the United States and erected on the Isthmus by the contractors for $5,374,774.82.

In addition to the foregoing the principal items purchased during the year were 4 steel barges, 2 tugboats, and 3 launches; 1 20-inch pipe line suction dredge; 1 dredging plant; 13 dredging, discharge, and relay pumps; 7 narrow-gauge locomotives; 1 steam shovel; 449 dump and flat cars; 1 earthspreader; 10 cranes; 1 pile driver; 2 rock crushers; 32 churn and rock drills; 8,745 tons steel rails; 655,842 cross ties; 32,715 piles; 30,771,744 feet of lumber; 14,742,400 pounds dynamite and blasting powder.

The shipments of cement for use in the locks and dams, purchased under the contract for 4,500,000 barrels, referred to in previous annual reports, were commenced in July, 1909, 904,727 barrels of cement called for in this contract having been delivered on the Isthmus up to June 30. The first shipment was made via the steamship *Ancon*, one of the two vessels purchased for this purpose and referred to in previous report, delivery by contractor at that time being at the rate of 2,000 barrels per day. This rate of delivery has been gradually increased until at the present time cement is being delivered by the contractor at the rate of 5,300 barrels per day.

Very respectfully,

F. C. Boggs,
Captain, Corps of Engineers, U. S. Army,
General Purchasing Officer, Chief of Office.

Col. George W. Goethals, U. S. Army,
Chairman and Chief Engineer,
Isthmian Canal Commission, Culebra, Canal Zone.

APPENDIX S.

CHARTS SHOWING ORGANIZATION OF ISTHMIAN CANAL COMMISSION AND PANAMA RAILROAD COMPANY, AUGUST, 1910.

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(For Plates, see Portfolio.)

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